Forecasting the Quantity of Shrimp and Dry Fish Export from Bangladesh

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Abstract
This study presents forecasting quantity of shrimp and dry fish export from Bangladesh for five years by using deterministic models that could be used to make efficient forecast of shrimp and dry fishes. These models are very much quick, inexpensive and capable of describing time series data adequately in many situations. In this study, nine different deterministic time series models have been considered. They are all fitted to data of shrimp & dry fish exports from Bangladesh. Among the deterministic type models, the cubic model is best for shrimp export and S-shaped model is more applicable for dry fish export. From this study, it has been found that the increase of shrimp export would be 4.93% annually or 24.67% over coming five years. The total amount would increase from 57017.56 thousand tones to 71081.6 thousand tones during 2010/11 to 2015/16. It has been observed that the quantity of dry fish export would increase by 0.46% annually. The total amount would increase by 2.30% i.e., from 355.30 thousand tones to 363.30 thousand tones during 2010/11 to 2015/16.
Keywords: Forecast, Shrimp export, Dry fish export.

Introduction

Bangladesh is a tropical country covering a land area of 147 thousand sq. km. The country is situated on the north-eastern side of South Asia and bounded by India on the west, north and east, by Myanmar on the east and by the Bay of Bengal on the south. In our country, agriculture (excluding forestry) contributes 18.32 percent of GDP during 2010-11 and 47% of the total labor force are engaged in agriculture. The majority of the population who lives in the rural areas depends on the primary sector for their livelihood (BBS, 2011).

Fishery sub-sector has been playing a vital role in the socio-economic context of Bangladesh. It has been contributing to the developing agro-based industries and creating employment opportunities for rural people. Frozen shrimp of coastal area, fish and fishery products occupy the third position in the country's export (DoF, 2010). Fishery sector accounts for 5.0 percent of GDP of the country in 2004-05, which decreased to 4.43 percent in 2010-11. Bangladesh earns every year a considerable amount of foreign exchange by exporting fish and fish products. The main items of fisheries exports are frozen shrimp, frozen fish and dry fish. The position of fish and fish products was third in the list of exporting products from Bangladesh (DoF, 2009).

A study (Hossain *et al*., 1999) predicted that if Bangladesh was able to convert 25% of her existing shrimp cultivable land into semi-intensive farming, foreign exchange earnings by exporting shrimps would be $961.33 million annually. Export sector appears to have a bright future both in employment opportunity and foreign exchange earnings in the years to come if necessary policies are taken for and appropriate supports are provided with the producer and exporters. Approximately, 1.4 million people depend on fisheries as their primary sources of income and another 11 million people are engaged in seasonal or part-time fishing and other ancillary activities and out of a total employment of 28 million in Bangladesh, approximately 7% is in fisheries (Nuruzzaman, 1995). Shrimp production in Bangladesh is increasing gradually through horizontal expansion of the farming area not by the desired vertical expansion (Bhattacharjee and Bhuiyan, 1995). But shrimp farming need not require a heavy investment though it bears a bright and prospective future in the years to come. There exists a high potential of employment prospect and earning from exporting shrimp that can be increased several times if only the existing problems relating to its production and marketing activities can be identified appropriately and essential policy measures can be taken timely. Dry fish sector is also an important sector for our economy. Marine dried fish export plays also an important role in the economy of Bangladesh, contributing to increased foreign exchange earnings.

Efficient forecasting of the future movement of shrimp and dry fish export can help policy makers in proper planning to develop the sector. For efficient forecasting, adequate mathematical models are necessary. Here, an attempt has been made to develop deterministic models for forecasting shrimp and dry fish export of Bangladesh. Deterministic models are very powerful and popular as they can, in many situations, successfully describe the observed data and can make forecast with minimum forecast error. The specific purpose of this study is to develop appropriate deterministic models for the time series of shrimp and dry fish export in Bangladesh and to make five years forecasts for both the time series with appropriate prediction interval.

Materials and Methods

The present study was conducted using secondary data on shrimp & dry fishes export earnings from Bangladesh during the period of 1972-73 to 2009-10. Data were collected from various publications of Bangladesh Bureau of Statistics (BBS, 1972/1973-2009-10). This is the only government level institute responsible for collecting and storing necessary data required for future planning and development of the country. In this study, for forecasting purpose, quantities of and earnings from shrimp & dry fishes export from Bangladesh have been estimated by using deterministic models.

Analytical procedure

The collected data were analyzed using SPSS and Microsoft Excel. Different methods of analysis were employed in accordance with the objectives of the study. Brief description of the analytical techniques is given below:

Deterministic models

If the process is such that the future values are exactly determined by some mathematical function and once have identified this function we can exactly predict future values of the time series, then the underlying process is said to be a deterministic model. Nine types of deterministic time series models which often called growth model were used for forecasting purpose. These are Linear, Logarithmic, Inverse, Quadratic, Cubic, Power, S-shape, Exponential and Compound growth models. Although they do not provide as much forecasting accuracy as the correctly identified and estimated stochastic time series model, in many cases they provide a simple, inexpensive and still quite acceptable means of forecasting. It is very important to note that these models are called deterministic in that no reference is made to the source and nature of the underlying randomness in the series (Pindyck, 1991).

Here, an attempt is made to searching the best models using the latest available model selection criteria for making forecasts of quantity of shrimp & dry fish exports from Bangladesh.

Table 1: The mathematical forms of the models considered and formulas of the growth rate

Name of the models	Mathematical forms	Meaning and assumption
Linear	$Y= a+ bt + \varepsilon$	Y is the time series considered. t represents taking integer values starting from 1. ε is the regression residual. a, b, c and d are the coefficient of models.
Logarithmic	$Y= a+ b \log_e t+ \varepsilon$	
Inverse	$Y= a+ b/t + \varepsilon$	
Quadratic	$Y= a+ bt +ct^2 + \varepsilon$	
Cubic	$Y= a+ bt + ct^2 +dt^3 + \varepsilon$	
Power	$Y=at^b e^{\varepsilon}$	
S-shape	$Y= e^{a+b/t+\varepsilon}$	
Exponential	$Y=ae^{bt\varepsilon}$	
Compound	$Y=ab^t e^{\varepsilon}$	

Source: Haque, 2004

Model selection criteria

To identify the best model for a particular time series, the latest available diagnostic tools are used. They are Coefficient of Determination (R^2), Adjusted Coefficient of Determination ($\bar{R}^2$), Root Mean Square Error (RMSE), Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), Mean Absolute Error (MAE), Mean Absolute Percent Prediction Error (MAPPE). In interpreting the criteria, author considered the higher value of R^2 or $\bar{R}^2$, the better is the fitness of model. On the other hand, smaller the values of RSME, AIC, BIC, MAE or MAPPE; the better is the fitness of the model (Gujarati, 2003).

Coefficient of determination (R^2)

The coefficient of determination, proposed by Theil (1961), is the ratio of the regression sum of square to the total sum of square i.e.

$$R^2 = \frac{\text{Regression sum of squares}}{\text{Total sum of squares}} = \frac{RSS}{TSS} = 1 - \frac{ESS}{TSS}$$

In interpretation R^2, it is generally considered that the more the value of R^2, the better is the fit. But there are some limitations in interpreting it in this way. One of the major limitations is that R^2 can overstate the value of a regression fit since the error sum of squares (ESS) can be reduced simply by adding further explanatory variables, even if they are not relevant to explaining the dependent variable.

Adjusted Coefficient of Determination ($\overline{R}^2$)
An alternative to R^2, denoted , which is adjusted for the degrees of freedom associated with regression and total sum of squares, is defined as :

$$\overline{R^2} = 1 - (1 - R^2)\frac{n-1}{n-k}$$

Where n is number of observation and k is the number of parameters to be estimated. In some cases particularly bad fit can be negative and it does not exist when the number of observations is less than or equal to the number of parameters to be estimated. Granger and New bold (1986), Johnston and some other econometricians recommended this alternative. The greater the value of this criterion, the more is the accuracy of the model.

Root Mean Square Error (RMSE)
The root mean square error is defined as

$$\text{RMSE} = \sqrt{\frac{1}{n-k}\sum_{t=1}^{n}\varepsilon_t^2}$$

Where, ε is the difference between actual and estimated values in time t, n is the number of observation and k is the total number of estimable parameters. The model with minimum RMSE is assumed to describe the data series more adequately.

Akaike Information Criterion (AIC)
Akaike Information Criterion (AIC), proposed by Akaike (1973), one of leading statisticians, provides guide lines for choosing the best possible model from a set of competing models. It is defined as:
AIC = n log (MSE) + 2k
Where n is the number of observation, MSE is the mean square error and k is the total number of estimated parameters. Akaike mentioned that the model with minimum AIC is closer to the best possible choice.

Schwartz information criterion (SIC)
Schwartz (1978) developed this criterion, which is alternative called Bayesian Information Criterion (BIC). This is defined as:

$$\text{BIC} = n \log (MSE) + k \log n$$

Where n is the number of observation, MSE is the mean square error and k is the total number of estimable parameters. Schwartz shows that BIC is better than AIC. The model with minimum BIC is assumed to describe data series more adequately.

Mean Absolute Error (MAE)
The Mean Absolute Error is defined as:

$$\text{MAE} = \frac{1}{n}\sum_{t=1}^{n}|\varepsilon_t|$$

The model with minimum MAE assumed to describe the data series adequately.

Mean Absolute Percent Prediction Error (MAPPE)
The Mean Absolute Percent Prediction Error (MAPPE) is defined as:

$$\text{MAPPE} = \frac{1}{n}\sum_{t=1}^{n}\frac{|\varepsilon_t|}{y_t}\times 100$$

The model with minimum MAPPE is assumed to describe the data series adequately.

Confidence interval
The concept of confidence interval is very much essential for the forecasting of Y_t. In this study 95% confidence interval of regression co-efficient has been used for forecasting. 95% confidence interval of Regression co-efficient = Regression co-efficient ± Standard error of Regression co-efficient

In this study, the term medium, high and low values have been used. Medium value is value of dependent variable estimated by using regression co-efficient alone, and when the value of regression co-efficient is used with plus or minus sampling error of regression co-efficient or (regression co-efficient ± standard error of regression co-efficient), the values of dependent variables are high values and low values respectively.

Results and Discussion
All the models are applied to estimate the coefficient for quantity of shrimp and dry fishes export from Bangladesh. Now selections of the best model for forecasting the quantity of shrimp and dry fishes are given below separately.

Quantity of shrimp export from Bangladesh

The estimated parameters for quantity of shrimp export from Bangladesh during 1972-73 to 2009-10 are exposed in Table 2. The parameters those are significant at 1 percent level marked by double star. The analysis shows that two coefficients of quadratic are highly significant at 1 percent level. All the diagnostic tools used in this study to identify the best fitted model for forecasting purpose and also for explaining the growth pattern are calculated and are given in the following Table 3. In interpreting the diagnostic tools it is considered that the more the value of R^2 or adjusted $\overline{R}^2$ the better is the fitness of the model. The smaller the value of RSME, AIC, SIC (BIC), MAE, MSE and MAPPE, the better is the fitness of the model selection criteria.

Table 2: Parameter estimates of the models for quantity of shrimp export from Bangladesh ('000 tones)

Model	Constant	Coefficient		
	a	b	c	d
Linear	-5320.107 (-2.351)	1383.180** (13.676)		
Logarithmic	-20354.201 (-3.735)	15502.187** (8.085)		
Inverse	27037.45** (9.578)	-48404.732 (-3.539)		
Quadratic	-640.715 (-0.188)	681.272** (1.691)	17.998** (1.797)	
Cubic	-4336.576 (-0.913)	1749.697** (1.680)	-49.610 (-0.805)	1.156 (1.112)
Power	186.793** (31.643)	1.555 (26.736)		
S-shape	10.162** (66.057)	-6.468 (8.678)		
Exponential	1493.683** (32.787)	0.109 (10.978)		
Compound	1493.683** (32.787)	1.1152 (10.978)		

**denote estimated coefficients are significant at 1% level of significance.

It appears in the Table 3 that the values of R^2 (0.689) or adjusted $\overline{R}^2$ (0.680) for power model are the highest in comparison to other models. On the other side, the coefficients of linear, logarithmic, quadratic and cubic models are significant except the constant part. Moreover the values of RMSE (297.36), AIC (444.1), BIC (440.1), MAE (235.22), MSE (88423.54) and MAPPE (40.88) are the smallest values from all the models. Maximum smallest number comes from cubic models. So, for making forecast with minimum error, the cubic model seems to be the best.

Table 3: Diagnostic of model selection for quantity of shrimp export from Bangladesh

Model	Criteria							
	R^2	Ad $\overline{R}^2$	RMSE	AIC	BIC	MSE	MAE	MAPPE
Linear	0.102	0.077	361.16	455.59	454.864	130437.59	292.82	72.60
Logarithmic	0.207	0.185	339.34	450.85	450.128	115152.46	265.41	60.21
Inverse	0.155	0.132	350.15	453.24	452.52	122604.65	287.99	61.34
Quadratic	0.388	0.353	298.07	444.1	440.27	88844.19	235.22	41.43
Cubic	**0.391**	**0.337**	**297.36**	**448.82**	**440.1**	**88423.54**	**237.98**	**40.88**
Power	0.689	0.680	455.62	475.30	474.58	219120.44	335.78	146.33
S-shape	0.625	0.615	391.51	461.72	460.1	153282.79	280.15	130.04
Exponential	0.404	0.388	537.03	485.74	485.02	288402.47	393.02	245.26
Compound	0.404	0.388	537.03	485.74	485.02	288402.47	393.02	245.26

Quantity of dry fish export

The estimated parameters of dry fish export from Bangladesh during 1972-73 to 2009-10 are presented in Table 4. The analysis shows that all the coefficients of the models are highly significant (at 1 percent) only for exponential and compound model. For linear & cubic model, constant and coefficient both part are non-significant. For logarithmic, quadratic and power, only one coefficient is significant but other part is not significant. For Inverse & S-shape models, only constant part is significant. So, it seems difficult at this stage to select the best model. That's why; we have to examine model selection criteria to identify the best fitted model for forecasting purpose.

Table 4: Parameter estimates of the models for quantity of dry fish export from Bangladesh ('000 tones)

Model	Constant	Coefficient		
	a	b	c	d
Linear	213.706 (1.740)	11.071 (2.017)		
Logarithmic	-116.632 (-.628)	201.953** (3.064)		
Inverse	525.746** (7.588)	-864.179 (-2.574)		
Quadratic	-279.817 (-1.755)	85.100** (4.513)	-1.898 (-4.048)	
Cubic	-343.376 (-1.520)	103.474 (2.090)	-3.061 (-1.045)	0.020 (0.402)
Power	0.6486 (-0.671)	2.026** (8.925)		
S-shape	6.117** (24.116)	-9.528 (-7.754)		
Exponential	14.70** (4.891)	0.121** (4.943)		
Compound	14.70** (4.891)	1.1286** (4.943)		

**denote estimated coefficients are significant at 1% level of significance

It appears from the Table 5 that the value of R^2 (0.689) & Ad $\overline{R}^2$ (0.680) are the higher for power model and the lowest values of model selection criteria are AIC (444.1), BIC (440.1), MSE (88423.54), RMSE (297.36), MAE (235.22) & MPPE (40.88). Most of the lowest values contain cubic model but the coefficients of this model are not significant. So, the second highest value of R^2 (0.625) & Ad $\overline{R}^2$ (0.615) are for S-shape model and the values of model selection criteria AIC (461.72), BIC (460.1), MSE (153282.79), RMSE (391.51) are smaller in comparison of others models. The performances of other models are also poor. So, the study revealed that S-shaped models are the best for quantity of dry fish export forecasting.

Table 5: Diagnostic of model selection for quantity of dry fish export from Bangladesh

Model	Criteria							
	R^2	Ad $\overline{R}^2$	RMSE	AIC	BIC	MSE	MAE	MAPPE
Linear	0.102	0.077	361.16	455.59	454.864	130437.59	292.82	72.60
Logarithmic	0.207	0.185	339.34	450.85	450.128	115152.46	265.41	60.21
Inverse	0.155	0.132	350.15	453.24	452.52	122604.65	287.99	61.34
Quadratic	0.388	0.353	298.07	444.1	440.27	88844.19	235.22	41.43
Cubic	0.391	0.337	297.36	448.82	440.1	88423.54	237.98	40.88
Power	0.689	0.680	455.62	475.30	474.58	219120.44	335.78	146.33
S-shape	**0.625**	**0.615**	**391.51**	**461.72**	**460.1**	**153282.79**	**280.15**	**130.04**
Exponential	0.404	0.388	537.03	485.74	485.02	288402.47	393.02	245.26
Compound	0.404	0.388	537.03	485.74	485.02	288402.47	393.02	245.26

The aforesaid discussion about the fitness of various models to the time series for quantity of shrimp and dry fishes export data found that not any particular, but different models are appropriate for shrimp and dry fishes export in describing the growth patterns. Investigating towards the fitness of as many as nine types of growth models to the quantity of shrimp & dry fish's export data is performed. For quantity of shrimp export, cubic model is applicable; implying that the growth rates of quantity of shrimp export was not constant throughout the study period, instead it was dependent on time with a cubic nature of variation. For quantity of dry fish export, S-shaped model is applicable.

It also reveals that the selection of the best model for shrimp and dry fishes can sometimes be very confusing. However, the discussion recommends the best model for shrimp and dry fishes export from Bangladesh as shown in Table 6.

Table 6: Best estimated models for quantity of shrimp & dry fishes export from Bangladesh

Variable	The name of the best model	The functional form of the model
Shrimp (Quantity)	Cubic	Y= -4336.576 + 1749.697**t -49.610t2 + 1.156t3 + e
Dry fishes export (Quantity)	S-shape	ln Y= 6.117-9.528/t + e

Forecasting of export quantity of shrimp and dry fish from Bangladesh

Forecasting of quantity export of shrimp and dry fish will be helpful to know what amount of shrimp and dry fishes have to export for earning foreign exchange in the future. This type of work will be helpful to the policy makers because they will estimate the quantity of export after fulfilling the domestic demand and can identify at what price they will be profitable by exporting this commodity.

The best fitted model for the quantity of shrimp and dry fishes export from Bangladesh used to make forecast with 95 % confidence interval are presented below in the Table 7 & 8. The prediction period extends from 2010/11 to 2015-16. An important limitation for making forecasts is that the forecasting error increases with the increase of the period of forecast. For this reason short term forecast are more reliable compared to the long term one.

Forecasting the quantity export of shrimp

The forecast values and confidence intervals exhibited in Table 7 would reveal that forecasting errors sufficiently small and consequently the intervals are not too large. The study estimated that if the present growth rates will continue then quantity of shrimp export from Bangladesh would be 71081.6 thousand tones in the year of 2014/15.

Table 7: Forecast for quantity of shrimp export (Thousand tones) from Bangladesh

Year	**Time series forecasting**		
	Lower limit	**Forecast**	Upper limit
2010/11	48492.43	57017.56	65542.81
2011/12	50697.1	60259.3	69821.62
2012/13	52953.87	63679.27	74404.79
2013/14	55263.44	67284.39	79305.46
2014/15	57626.51	71081.6	84536.81
Percentage of total change over 5 year	18.84	24.67	28.98
Percentage of average change over 5 year	3.77	4.93	5.80

$$\text{Percentage of total change over 5 year} = \frac{\text{Figures of (2014/15) - Figures of (2010/11)}}{\text{Figures of (2010/11)}} \times 100$$

Percentage of average change over 5 year

$$= \frac{\text{Percentage of total change over 5 years}}{\text{Figures of (2010/11)}} \times 100$$

From the extrapolation of time series data of shrimp export indicated the increase of 4.93% annually or 24.67% over coming five years. The total amount would increase from 57017.56 thousand tones to 71081.6 thousand tones during 2010/11 to 2015/16. it was observed that quantity of dry fish export would increase by 0.46% annually. The total amount would increase by 2.30% i.e., from 355.30 thousand tones to 363.30 thousand tones during 2010/11 to 2015/16.

Forecasting the quantity export of dry fishes

Close examination of the forecasting values and confidence intervals presented in Table 8 would find forecasting errors as adequately small and so the intervals are not too large. The study indicated that if present growth rates continue then quantity of dry fish export from Bangladesh would be 363.45 thousand tones in the year of 2015/16. The study revealed that S-shape model is appropriate for dry fish export from Bangladesh.

Table 8: Forecast for quantity of dry fish export (Thousand tones) from Bangladesh

(Value in thousand tones)

Year	**Time series forecasting**		
	Lower limit	**Forecast**	Upper limit
2010/11	344.27	355.30	366.67
2011/12	346.65	357.47	368.62
2012/13	348.93	359.55	370.49
2013/14	351.12	361.54	372.28
2014/15	353.21	363.45	373.99
Percentage of total change over 5 year	2.0	2.30	2.60
Percentage of average change over 5 year	0.40	0.46	0.52

Percentage of total change over 5 year= $\frac{\text{Figures of (2014/15) - Figures of (2010/11)}}{\text{Figures of (2010/11)}} \times 100$

Percentage of average change over 5 year

$$= \frac{\text{Percentage of total change over 5 years}}{\text{Figures of (2010/11)}} \times 100$$

On the other side, extrapolation of time series data, it was observed that quantity of dry fish export would increase by 0.46% annually. The total amount would increase by 2.30% i.e., from 355.30 thousand tones to 363.30 thousand tones during 2010/11 to 2015/16.

Conclusion

On the basis of findings of the study, it may be concluded that earnings from shrimp and dry fish show positive growth per annum during the whole study period. The increasing rate in forecasting of shrimp export for five years is satisfactory. Forecasting of dry fish exports increases but rate of increase is very small. Well developed and systematic export promotion program is needed for shrimp and dry fish exports which will have a significant impact on both agriculture and economic development. By exporting shrimps and dry fish in the world market, production needs to be increased which in turn can generate domestic demand by opening up employment opportunities. Considering the importance, the present study will undoubtedly be useful for Bangladesh government in policy formulation, planning and developing programs for improving growth of shrimp and dry fish, reducing instability in shrimp and dry fish export and determining the quantity of shrimp and dry fish to be exported from Bangladesh. These empirical findings can be significant source of information for the producers, traders, exporters, policy makers and researchers to build foundation for further research in this sector.

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