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Forecasting of Milk, Meat and Egg Production in Bangladesh

Md. Jamal Hossain and Md. Fuad Hassan
Department of Agricultural Statistics, Bangladesh Agricultural University, Mymensingh, BANGLADSEH

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Abstract

Livestock plays an important role in the national economy of Bangladesh. Milk, meat and egg production forecast have recently received a great deal of attention for planning and policy purposes. With this in mind, the present study was undertaken to find out appropriate deterministic type growth model using latest model selection criteria that could best describe the growth pattern of milk, meat and egg production in Bangladesh during the time periods 1991-92 to 2011-12. The study revealed that the cubic model is the best fitted model for milk, meat and linear model is the best for egg production. The selected model was used for succeeding four years forecast with a 95% confidence interval of milk, meat and egg production. The analysis found that if the present growth rates continue then the production of milk, meat and egg would be 4.55, 3.77, and 7544.67 million tons, respectively, in the year 2015-16. The findings of this study will help the policy makers to take necessary actions for proper management of milk, meat and egg production according to their demand and supply.

Keywords: Forecasting, livestock production, growth model.

Introduction

Livestock plays an important role in the national economy of Bangladesh with a direct contribution of around 3% percent to the agricultural GDP and providing 15 percent of total employment in the economy, BER[1]. The livestock sub-sector that includes poultry offers important employment and livelihood opportunities particularly for the rural poor, including the functionally landless, many of whom regard livestock as a main livelihood option, DLS[2]. About 75 percent people rely on livestock to some extent for their livelihood, which clearly indicates that the poverty reduction potential of the livestock sub-sector is high, Tareque et al[3]. It is an established fact that high quality animal protein in the form of milk, meat and eggs is extremely important for the proper physical and mental growth of human being. In Bangladesh, around 8% of total protein for human consumption comes from livestock. As per FAO estimates the demand and availability of milk, meat and egg for the country in the Year 2007-08, it is evident that there is a deficit of (80%) in milk, 82% in meat and 63% in eggs[4]. Livestock Department's available statistics show that the domestic production of milk, meat and egg are 3.46, 2.33, and 7303 million tons in the fiscal year 2011-2012 against the demand of 13.50, 6.48, and 15392 million tons respectively[5].

Evaluation of the production pattern of milk, meat, egg in Bangladesh may serve as an aid for policy makers in taking decision regarding production, procurement, export, import etc. To reveal the production pattern and to make the best forecasts of milk, meat, egg production in Bangladesh appropriate time series models that best describe the observed data successfully are necessary. For forecasting purpose two types of time series models are widely used in practice. The first type is known as deterministic time series model and second type is known as stochastic time series model. Deterministic type time series models, often called growth models, such as linear, quadratic, cubic, logarithmic, exponential, compound, inverse, power, and S-shaped are very quick to estimate, inexpensive and very easy to understand. Although they do not provide as much forecasting accuracy as the correctly identified and estimated stochastic time series models in many cases they provide a simple, inexpensive 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 sources and nature of the underlying randomness in the series defined by Pindyck et al[6]. These models are widely used to estimate the growth rate of time series. Before performing growth analysis it is necessary to identify the growth model that best fits the time series. Here, an attempt is made to identify the best models for milk, meat, egg production in Bangladesh using the latest available model selection criteria such as R^2, $\bar{R}^2$, RMSE, AIC, BIC, MAE and MAPE[7,9]. Attempts are also made to describe the growth scenario and to make forecasts of milk, meat, egg production in Bangladesh using the best fitted models.

Material and Methods

Data and Models: The study was conducted using secondary time series data of milk, meat and egg production in Bangladesh from 1991-1992 to 2011-2012. These yearly data of milk, meat and egg production have been collected from the various publications of Bangladesh Bureau of Statistics (BBS). These secondary data are used to analyze and achieve the specific objectives of the study.

The growth models are used to describe the behaviour of variable varying with respect to time. In these models integrated variable exhibits a systematic variation or trend. If the trends are completely predictable, it is called as deterministic trend. The specification of a deterministic trend can be any functional form of time. The deterministic trend can be any functional form of the following:

$$DT = \alpha + \beta t \quad (Linear\ trend)$$

$$DT = \sum_{i=0}^{k} \rho_i t^i \quad (polynomial\ time\ trend)$$

It is 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. For forecasting purpose different deterministic type of time series models are used, also known as growth models. This type of model is needed in specific area of a specific problem that depends on type of growth that occurs in the time series data. Linear, logarithmic, quadratic, cubic, exponential, compound, inverse, power, and S-shaped are well known growth models. In this study five deterministic type growth models are considered for study purpose. These models are: Linear Model, Quadratic Model, Exponential Model, Compound Model and Cubic Model. Table 1 shows the variations among the nature of the different growth rates for different models.

Growth rates for linear, exponential and compound models are independent of time. The growth rate in linear model is constant in its absolute value throughout the time interval in its percentage value. But growth rates for other models depend on time. The basic difference between the exponential and compound model is in the value and interpretation of the value of the β coefficients of the two models. Forecast obtained by these models can often be usefully combined with other forecasts in order to get superior overall forecasts.

Model Selection Criteria: Model selection is an important part of any statistical analysis. Most of the procedures for choosing between two competing econometric models take the following form: each econometric model is estimated by a method that solves some optimization problem; the models are then compared by defining an appropriate goodness-of-fit or selection criterion for each model; and the better-fitting model according to this criterion is selected[8].

In this study several model selection criteria are used which are given in table 2. Interpretation of the model selection criteria considered that the more the value of R^2 and $\bar{R}^2$, the better is the fitness of the model. On the other hand, the smaller is the value of RMSE, AIC, BIC, MAE, and MAPE, the better is the fitness of the model.

Results and Discussion

Description of the original series: The milk, meat and egg production in Bangladesh during the period of 1991-92 to 2011-12 is presented in figure 1. The production of milk increases slowly from 1991-92 to 2007-08 then rapidly falls in 2008-09 and grew more rapidly to the end of 2009-10. The figure reveals that meat production followed an upward trend from 1991-92 to 2005-06. Though meat production increased sharply from 2009-10 to 2011-12 it cannot fulfill the domestic demand of the country as in 2012 meat production was 2.33 million tons but its demand was 6.48 million tons. On the average egg production increases slowly throughout the year with certain ups and downs and followed an upward trend. Meat, milk and egg production have increased significantly from 1991-92 to 2011-12 years, but the availability of these food items is less than required for a nutritionally balanced diet.

Selecting the best deterministic growth model : Milk production in Bangladesh: The estimated parameters of milk production in Bangladesh during 1991-92 to 2011-12 have been presented in table 3. The analyses revealed that the constant part of all models and linear part of all models except quadratic model are highly significant at 1% significance level. The quadratic part of cubic model is found insignificant but constant, linear, and cubic part is found significant. It seems difficult at this stage to select the best model but looking at the model selection criteria's will be helpful. The tools that have been used in this study to be acquainted with the best-fitted model for forecasting purpose and also for explaining the growth pattern are calculated and shown in table 4.

Table- 1
Mathematical forms of different growth models

Name of the Models	Mathematical Form	Meaning of Notations
Linear	$Y_t = \alpha + \beta t + \epsilon$	Y_t is the time series considered t represent time taking integers values starting from 1 ϵ is the regression residual α, β, γ are the coefficient of the model
Quadratic	$Y_t = \alpha + \beta t + \gamma t^2 + \epsilon$	
Cubic	$Y_t = \alpha + \beta t + \gamma t^2 + \delta t^3 + \epsilon$	
Compound	$Y_t = \alpha \beta^t e^{\epsilon}$	
Exponential	$Y_t = \alpha e^{\beta t \epsilon}$	

Table- 2
Mathematical form of the model selection criterion

Selection Criterion	Notations
$AIC = n\log(MSE) + 2K$ $BIC = n\log(\text{MSE}) + K\log n$ $R^2 = 1 - \frac{\text{Error sum of square}}{\text{Total Sum of square}}$ $\bar{R}^2 = 1 - (1\text{-}R^2)\frac{n-1}{n-k}$ $MSE = \frac{1}{n-k}\sum \hat{\epsilon}_t^2$ $RMSE = \sqrt{\frac{1}{n-k}\sum \hat{\epsilon}_t^2}$ MAE= $\frac{1}{n}\sum_{t=1}^{n} \lvert\hat{\epsilon}_t\rvert$ MAPE = $\frac{1}{n}\sum_{t=1}^{n} \lvert\frac{\hat{\epsilon}_t}{Y_t}\rvert \times 100$	AIC: Akaike Information Criterion BIC: Bayesian Information Criterion R^2:Coefficient of Determination $\bar{R}^2$: Adjusted Coefficient of Determination MSE: Mean Squared Error RMS: Root Mean Square Error MAE: Mean Absolute Error MAPE: Mean Absolute Percent Error k is the number of parameters in the statistical model, n is the sample size, Y_t is the observed value, $\hat{\epsilon}_t$ is the difference between the observed and estimated values.

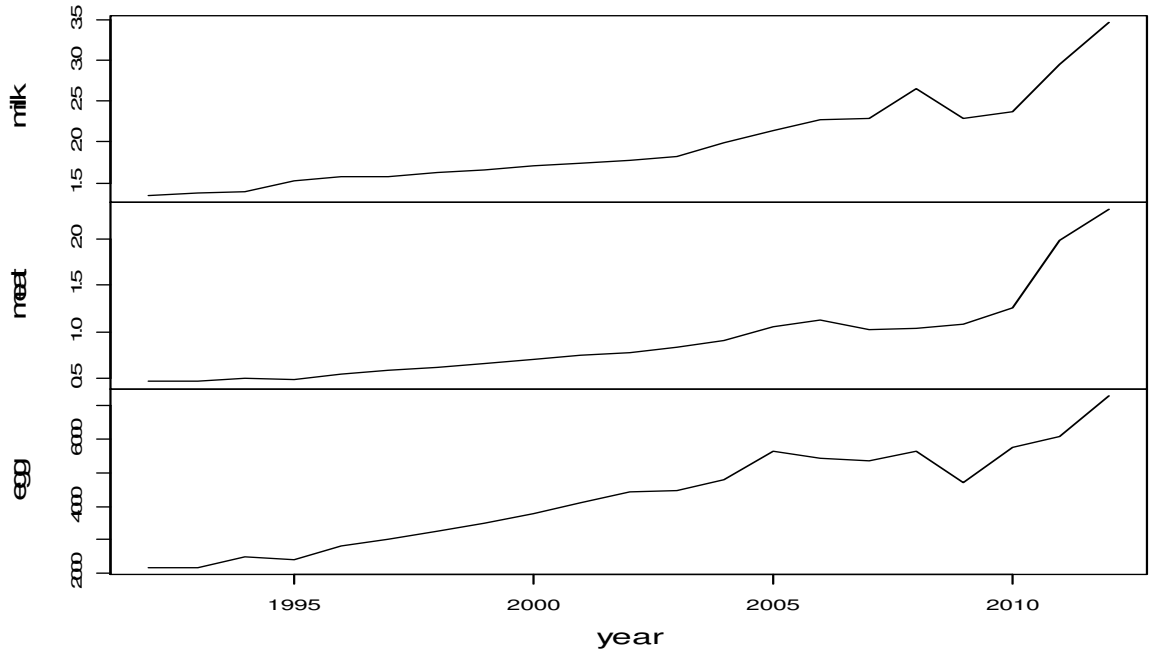

Figure- 1
Milk, meat and egg production (million tons) of Bangladesh (1991-92 to 2011-12)

Table- 3
Parameter estimates of the different growth models of milk production in Bangladesh

Model	Parameter			
	α	β	γ	δ
Linear	1.073**	.082**		
Quadratic	1.448**	-0.016	0.004**	
Compound	1.229**	1.041**		
Cubic	1.2093**	0.1011**	-0.0085	0.0004*
Exponential	1.229**	0.040**		

The asterisks ** and * indicate the statistical significant at 1% and 5% levels, respectively.

The value of $R^2(0.937)$ and $\bar{R}^2(0.926)$ are higher for cubic model compared to the linear, compound, quadratic, and exponential models. The value of RMSE (0.1507), AIC (-71.482), BIC (-67.304), MAE (0.0854), and MAPE (3.7902) are also lower for cubic model compared to other growth models. Figure 2 represents the observed and predicted (by cubic model) milk production. So, for describing the growth pattern of milk production in Bangladesh and making forecast with minimum error, the cubic model is the best.

Meat production in Bangladesh: The estimated parameters of meat production in Bangladesh during 1991-92 to 2011-12 have been presented in table 5. It shows that the regression coefficients of all models are highly significant except quadratic model. Except constant part all coefficients of cubic model is found significant. The diagnostic tools may disclose the picture more clearly. The value model selection criteria's are calculated and shown in table 6.

It appears from the table that the values of $R^2(0.922)$ and $\bar{R}^2(0.915)$ are the highest and RMSE (0.1555), AIC (-70.167), BIC (-65.989), MAE (0.1092), and MAPE (8.4375) are the lowest for cubic model in comparison with other models. Figure 3 represents the observed and predicted (by cubic model) meat production. So, for describing the growth pattern of meat production in Bangladesh and making forecast with minimum error, the cubic model is the best.

Table- 4
Criteria of model selection for milk production in Bangladesh

Model	R^2	$\bar{R}^2$	MSE	RMSE	AIC	BIC	MAE	MAPE
Linear	0.849	0.841	0.0487	0.2208	-59.447	-57.358	0.1616	7.7619
Quadratic	0.921	0.912	0.0268	0.1637	-70.008	-66.874	0.1024	4.8011
Compound	0.926	0.922	0.0354	0.1883	-66.136	-64.047	0.1186	5.2396
Exponential	0.926	0.922	0.0354	0.1883	-66.136	-64.047	0.1186	5.2396
Cubic	**0.937**	**0.926**	**0.0227**	**0.1507**	**-71.482**	**-67.304**	**0.0854**	**3.7902**

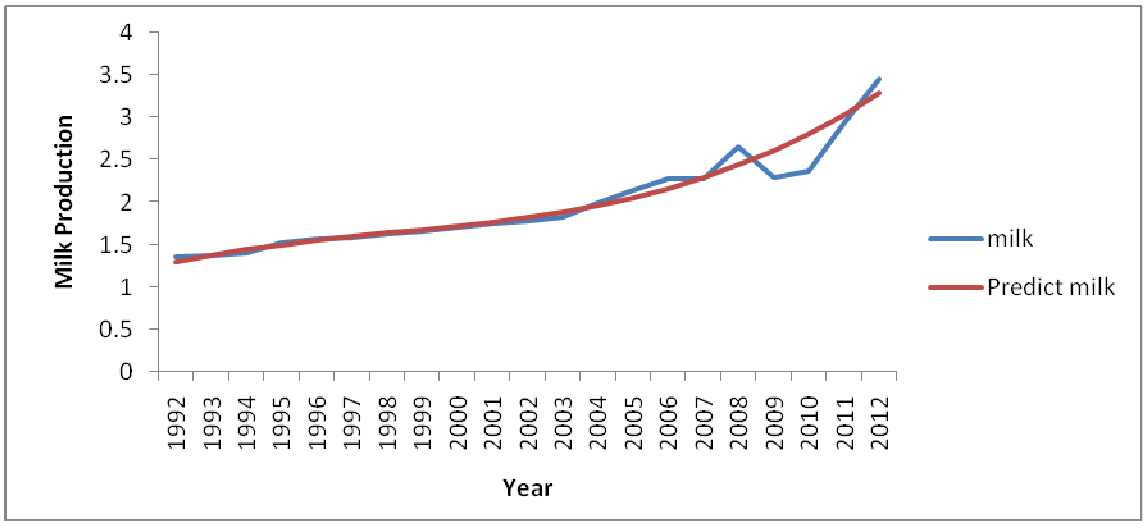

Figure- 2
Observed and predicted (by cubic model) milk production

Table- 5
Parameter estimates of the different growth models of meat production in Bangladesh

Model	Parameter			
	α	β	γ	δ
Linear	0.175	0.067**		
Quadratic	0.595**	-0.042	0.005**	
Compound	0.382**	1.072**		
Cubic	0.221	0.141**	-0.015*	0.001*
Exponential	0.382**	0.070**		

The asterisks ** and * indicate the statistical significant at 1% and 5% levels, respectively

Egg production in Bangladesh: The estimated parameters of egg production in Bangladesh during 1991-92 to 2011-12 have been presented in table 7. The analyses revealed that all the coefficients of linear, compound and exponential models are highly significant at 1% significance level. The quadratic coefficient of quadratic model and except constant all other coefficients of cubic model is found insignificant. It seems difficult at this stage to select the best model but looking at the model selection criteria's will be helpful. The tools that have been used in this study to be acquainted with the best-fitted model for forecasting purpose and also for explaining the growth pattern are calculated and shown in table 8.

The results show that the values of $R^2(0.939)$ and $\bar{R}^2(0.936)$ are the highest and RMSE (384), AIC (253.93), BIC (256.02), MAE (222.15), and MAPE (4.926) are the lowest for linear model in comparison with other models. Figure 4 represents the observed and predicted (by linear model) egg production. So, for describing the growth pattern of egg production in Bangladesh and making forecast with minimum error, the linear model is the best.

Table- 6
Criteria of model selection for meat production in Bangladesh

Model	R^2	$\bar{R}^2$	MSE	RMSE	AIC	BIC	MAE	MAPE
Linear	0.743	0.729	0.0633	0.2517	-53.942	-51.853	0.1692	17.2248
Quadratic	0.862	0.846	0.0360	0.1897	-63.828	-60.694	0.1269	12.6431
Compound	0.919	0.914	0.0441	0.2101	-61.527	-59.438	0.1093	8.5377
Exponential	0.919	0.914	0.0441	0.2101	-61.527	-59.438	0.1093	8.5377
Cubic	**0.922**	**0.915**	**0.0242**	**0.1555**	**-70.167**	**-65.989**	**0.1092**	**8.4375**

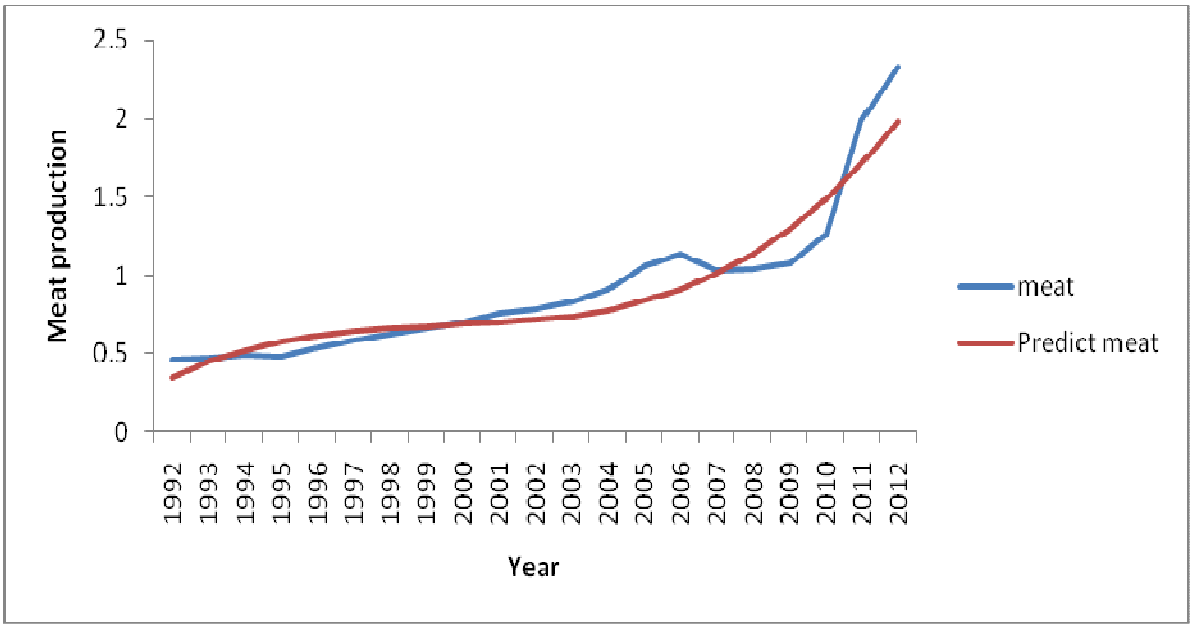

Figure- 3
Observed and predicted (by cubic model) meat production

Table- 7
Parameter estimates of the different growth models of egg production in Bangladesh

Model	Parameter			
	α	β	γ	δ
Linear	1758.474*	226.725*		
Quadratic	1738.414*	231.958*	-0.238	
Compound	2141.282*	1.059*		
Cubic	1686.460*	257.388	-3.061	0.086
Exponential	2141.282*	0.057*		

The asterisk * indicate the statistical significant at 1% level.

The aforesaid discussion, the fitness of various models to the time series of milk, meat and egg production stated that not any particulars, but different models are appropriate for different production in describing the growth patterns.

Forecasting: The best-fitted models for milk, meat and egg production in Bangladesh as used to make forecast with 95 percent confidence interval are presented in tables 9. The prediction period extends from 2012-13 to 2015-16.

Table- 8
Criteria of model selection for egg production in Bangladesh

Model	R^2	$\bar{R}^2$	MSE	RMSE	AIC	BIC	MAE	MAPE
Linear	**0.939**	**0.936**	**147453.15**	**384.00**	**253.93**	**256.02**	**222.150**	**4.926**
Quadratic	0.934	0.927	155574.48	394.43	257.05	260.19	222.150	4.941
Compound	0.938	0.935	205827.61	453.68	260.93	263.02	303.380	6.846
Exponential	0.938	0.935	205827.61	453.68	260.93	263.02	303.380	6.846
Cubic	0.934	0.922	164457.63	405.53	260.22	264.40	226.981	5.110

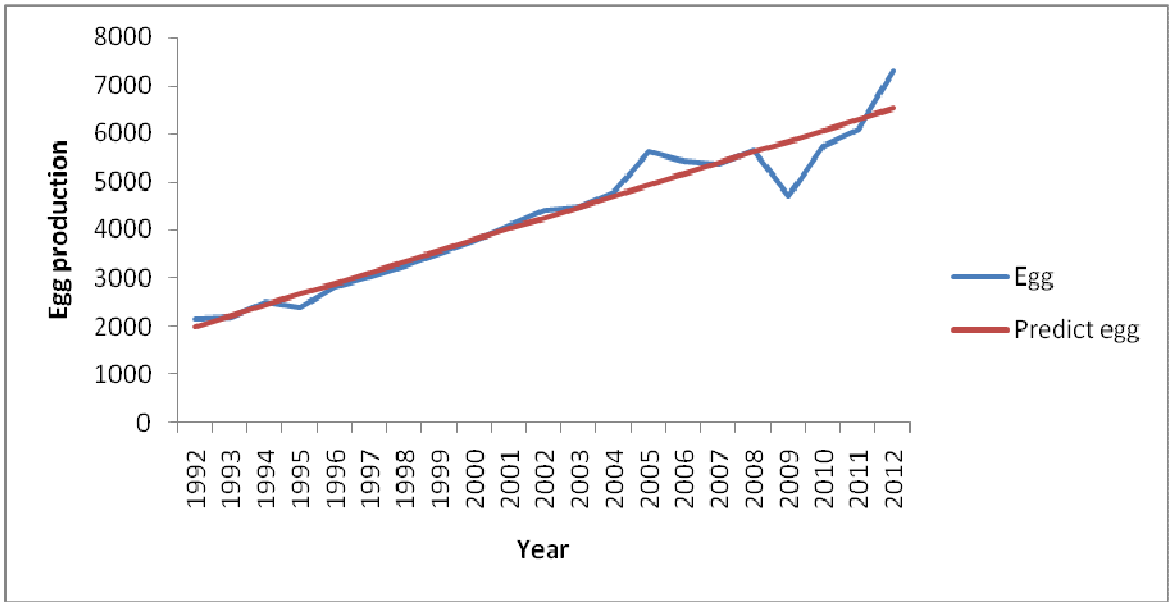

Figure- 4
Observed and predicted (by liner model) egg production

Table- 9
Forecast of milk, meat and egg production (million tons) in Bangladesh for the succeeding four years with 95 percent confidence interval

Model	Description	Forecast year			
		2012-13	**2013-14**	**2014-15**	**2015-16**
Milk (Cubic)	Lower limit	3.03	3.24	3.45	3.66
	Forecast	3.49	3.81	4.16	4.55
	Upper limit	3.96	4.37	4.87	5.44
	Length of CI	0.92	1.13	1.41	1.77
Meat (Cubic)	Lower limit	1.97	2.25	2.54	2.86
	Forecast	2.45	2.83	3.27	3.77
	Upper limit	2.92	3.42	4.00	4.68
	Length of CI	0.95	1.17	1.46	1.83
Egg (Linear)	Lower limit	5534.43	5506.56	5382.13	5160.14
	Forecast	6778.33	7027.92	7283.20	7544.67
	Upper limit	8022.22	8549.28	9184.27	9929.21
	Length of CI	2487.80	3042.72	3802.14	4769.07

An important drawback of making forecasts is that the forecasting error increases as the period of forecast increases. For this reason, short-term forecast is more reliable compared to long run forecast. The table 9 shows that forecasting errors are adequately small and consequently the intervals are not too large. The study showed that if the present growth rates remain same then the milk, meat and egg production in Bangladesh would be 4.55, 3.77, and 7544.67 million tons in 2015-16.

Conclusion

Time series analysis comprises methods for analyzing time series data in order to extract meaningful statistics and other characteristics of the data. Time series forecasting is the use of a model to predict future values based on previously observed values. In this study five deterministic time series models are considered. The model cubic was found appropriate for both milk and meat production, while linear model was appropriate for egg production. It meant that the annual growth rates were significantly different from time to time. Forecasts of milk, meat and egg production in Bangladesh were made for four succeeding years. If the present growth rates continue then the milk, meat and egg production in Bangladesh would be 4.55, 3.77, and 7544.67 million tons in 2015-16. The findings of this study would be more useful for policy makers, researchers as well as producers in order to forecast future national milk, meat and egg production more accurately in the short run. This study forecast some future production which would have the policy planners to take necessary action for the time to come. Basically forecasting accuracy relies on accuracy of the data on the interested variables. Data banks in our country should be well organized to get the best result by the forecasting models.

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