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FORECASTING OF WHEAT PRODUCTION IN BANGLADESH

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Abstract

The present study was undertaken to find out appropriate model using seven contemporary model selection criteria that could best describe the growth pattern of wheat production in Bangladesh and its three major areas like Dmajpur, Rajshahi, and Rangpur districts during the time periods 1971-72 to 2004-05. It appeared from the study that the best fitted model for wheat production in Bangladesh, Dinajpur, Rajshahi, and Rangpur were quadratic, linear, and cubic model. It means that the assumption of constant annual rate of growth in percent that lies behind the use of exponential/compound model which is very common in describing growth pattern was not true for the growth pattern of wheat production in Bangladesh. In Dinajpur District, linear model seemed to be appropriate. Five-years' forecasts of wheat production in Bangladesh, Dinajpur, Rajshahi, and Rangpur districts in the year 2005/06 were 1.55, 0.31, 0.24, and 0.37 million tons, respectively, with a 95 percent confidence interval. The analysis found that if the present growth rates continue then the wheat production in Bangladesh, and Dinajpur, Rajshahi, and Rangpur districts would be 1.54, 0.35, 0.31, and 0.59 million tons, respectively, in the year 2009/10.

Keywords : Forecasting, wheat production in Bangladesh.

Introduction

Rice and wheat are the principal sources of food, calorie, and protein intake for most of the people of Bangladesh. Once wheat was a food for the poorer in Bangladesh. Most of the people used to take wheat as 'Chapati' (locally known as ruti). The dietary habit of people of Bangladesh has changed to a considerable extent during the past decade. Wheat has now become an indispensable food item of the people of Bangladesh and it continues to fill the food gap caused by possible failure of rice crop. Within a period of 30 years of time, wheat has been firmly established as a secure crop in Bangladesh, mainly due to stable market price and two million farmers are currently involved in wheat production. Wheat cultivation is easier and requires less time and irrigation than other alternative crops like Boro rice, legumes, and potatoes; additionally it has low cultivation costs.

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Wheat is the second most important staple food crop in Bangladesh after rice. Its importance as a food and nutrition security crop has increased since independence. Wheat production has increased steadily from around 0.115 million tons in 1971-72 and gradually decreased to 0.73 million tons in 2005-06 (BBS, 2006). Besides, per capita intake of wheat stands at 28-30 g/day, indicating its approximate demand at 4 million tons per annum. The facts of past three decades indicated the increasing trend of wheat consumption. To meet increasing consumers' demand, the country has to import, on an average, 1.4 million tons of wheat every year. Moreover, wheat consumption is increasing due to rapid urbanization and industrialization of the country and the consequent increase in the use of numerous bakery products. Moreover, livestock and poultry thrive on wheat grain as a part of the ration and feed channels utilize most of the wheat by-products from flour milling. The straw may be fed as a part of the roughage for ruminants and is used extensively for livestock bedding (Islam, 1986). In view of the prevailing situation, rice alone is no more capable of providing balanced and nutritious food for the human, poultry, and livestock. The sufficient quantity of wheat can improve the nutrition situation in the country (Wadud *et. al.,* 2001).

For forecasting purpose, we have used the deterministic types of time series models which are often called growth models also. Such models are linear, logarithmic, quadratic, cubic, exponential, compound, inverse, power, and S-shaped model which are very easy to understand. 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 (Pindyck *et al.,* 1991). These models are widely used to estimate the growth rate of time series data.

A very common practice to estimate the growth rate of rice production in Bangladesh is the use of exponential or compound model (Akter *et al.,* 2002; Barua *et al.,* 2000; Jabber *et al.,* 1997; Hossain, 1984 and 1980; and Mahmud *et al.,* 1983). This model is appropriate when the annual percent growth rate is constant over time. If the growth rate is not constant, but depends on time instead this model can not describe the actual picture of growth scenario. So, before performing growth analysis it is necessary to estimate the growth model that best fits the time series. Here, an attempt is made to identify the best models for wheat production in Bangladesh using nine contemporary model selection criteria, such as R^2 adjusted R^2, RMSE, AIC, BIC, MAE, and MAPPE (Gujarati, 2003).

Objectives of the study

To forecast wheat production in Bangladesh as well as major wheat producing districts in Bangladesh using the best fitted models.

Methodology

The study was conducted using secondary time series wheat production data for Bangladesh and its three major wheat growing districts, namely Dinajpur, Rajshahi, and Rangpur during the period from 1971-72 to 2004-05. The data were collected from the various publications of Bangladesh Bureau of Statistics. The models those are used to describe the behaviour of variables that vary with respect to time are termed as growth models. This type of models is needed in a specific area and in a specific problem that depends on the type of growth that occurs in the time series data. In this study, Linear, Logarithmic, Inverse, Quadratic, Cubic, Power, S-Shape, Exponential, and Compound growth models are considered. In case of two or more competing models passing the diagnostic checks, the best model is selected by using the criteria Coefficient of Determination (R^2), Adjusted Coefficient of Determination ($\overline{R}^2$), Root Mean Squared Error (RMSE), Akaike Information Criterion (AIC), Bayesian Information (BIC), Mean Absolute Error (MAE), and Mean Absolute Percent Error (MAPE) which has been used in this study

Results and Discussion

Looking at the original series

The wheat production in Bangladesh had a long-term upward trend during the period from 1971 to 2000. The wheat production rapidly falls in 1973-74 and grew more rapidly to the end of 1974-75. In 1971-72, the wheat production was 0.11 million tons after 34 years in 2005, it was about 0.98 million tons. In Dinajpur, wheat production was only 0.0061 million tons in 1971-72 and it grew rapidly from 2002-03 to the end of the time period after a sharp fall in 2004-05. In 2004-05, wheat production of Dinajpur was observed 0.19 million tons. In Dinajpur, wheat production revealed three production jumps. The first jump was in 1975-76 when wheat production was 0.015 million tons and the second jump was observed in 1986-87 when wheat production was 0.11 million tons. The last jump was observed in 2001-02 when wheat production was 0.34 million tons. In Rajshahi, wheat production was 0.016 million tons in 1971-72 and it grew rapidly. In 1986-87, the wheat production was 0.11 million tons, then it rapidly fell in 1987-88, then again wheat production increased upto 2001-02 and it was 0.20 million tons. Again the wheat production gradually decreased. In Rangpur, the wheat production was 0.006 million tons in 1971-72 then it decreased upto 1973-74. After 1974-75, the wheat production in Rangpur rapidly increased upto 2000-01 and then it decreased gradually. So, growth of wheat production is not significant to meet increasing food requirement of the country.

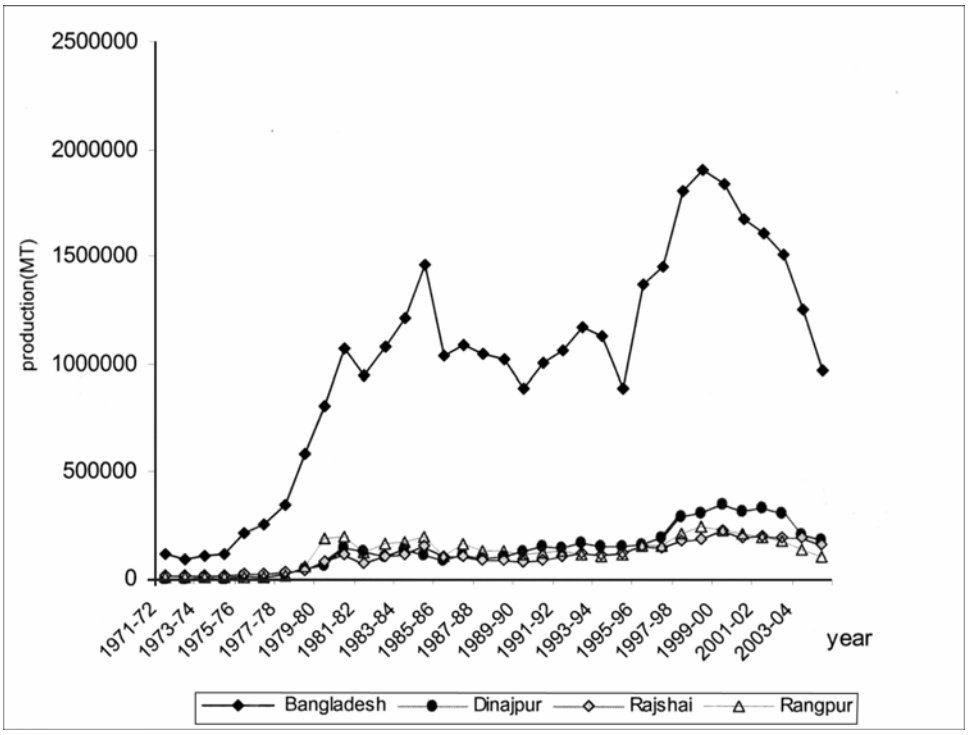

Fig. 1. Wheat production in Bangladesh with different regions

Best selection model

Wheat production in Bangladesh: The estimated parameters of wheat production in Bangladesh during 1971-72 to 2004-05 have been presented in Table 2. The parameters those are significant at 1% significant level are marked by double star and single star is used to present coefficients those are significant at 5% level. The analyses revealed that the coefficients of all models are highly significant except the cubic model. In these models, linear part i.e., b is significant at 1% level and rest of the parts quadratic and cubic part are insignificant. Since all coefficients are significant for quadratic model, it seems that the assumption of constant annual rate of growth in percent that lies behind the use of compound or exponential is not true for the growth pattern of wheat production in Bangladesh.

At this stage, the growth rate of wheat production in Bangladesh during the period was not constant as an exponential or compound model assumes. But, before taking the decision to examine the model selection criteria were used. The results are presented in Table 2. In interpreting the criteria, we considered the more value of R^2 or $\bar{R}^2$, the better is the fitness of the model. Smaller value of RMSE, AIC, BIC, MAE, and MAPPE are better fitness of the model. Obviously,

a better model yields smaller forecasting error. From the results of the model selection criteria shown in Table 2, it appears that the value of R^2 (0.80) or $\overline{R}^2$ (0.78) for the quadratic and cubic model are same in comparisons of other models. Moreover, the values of RMSE (228194), AIC (822), BIC (826), MAE (184631.37), MSE (52072530528), and MAPPE (29) are the smallest for quadratic model in comparison of other models. So, for describing the growth pattern of wheat production in Bangladesh and making forecast with minimum error, the quadratic model seems to be the best.

Table 1. Parameter estimates of the models of wheat production in Bangladesh

Model	Parameter				
	a	b	c	d	DW
Linear	191973.77** SE=94224.59	47866.50* SE=4835.74			
Logarithmic	-391108.54* SE=145364.76	541944.82** SE=53591.18			
Inverse	1236467.52** SE=85887.74	-1 862450.02** SE=388231.18			
Quadratic	-72593.31 SE=135472.63	93220.86** SE=18370.70	-1333.95* SE=524. 16		
Cubic	-213962.22 SE=190742.52	139683.84** SE=47862.22	-4699.87 SE=3245.14	65.99 SE=62.79	
Power	62706.11** SE=12019.10	0.97** SE=0.07			
S-Shape	14.02** SE=0.12	3.76** SE=0.54			
Exponential	210972.04** SE=39581.06	0.07** SE=0.009			
Compound	210972.04** SE=39581 .06	1.079** SE=0.010			

Wheat production in Dinajpur: The analyses indicated that coefficient of all models are highly significant except cubic and quadratic model (Table 3). The linear part of quadratic model is significant, but all the coefficient, of cubic model are insignificant. As all the coefficients are significant for linear model, it seems that the assumption of constant annual rate of growth in percent that lies behind the use of compound or exponential is true for wheat production in Dinajpur District.

Table 2. Diagnostic of model selection for wheat production in Bangladesh.

Model	Criteria							
	R^2	$\bar{R}^2$	RSME	AIC	BIC	MAE	MSE	MAPPE
Linear	0.76	0.75	256370.30	825.98	828.98	210406.69	65725731206	44.76
Logarithm	0.76	0.75	252215.76	824.91	827.90	207305.42	63612792736	49.03
Inverse	0.43	0.40	396165.36	854.71	857.70	311185.02	1.56947E+11	95.93
Quadratic	0.80	0.78	228194.06	821.53	826.02	184631.37	52072530528	29.23
Cubic	0.81	0.78	232499.14	822.30	828.29	188038.56	54055852400	31.69
Power	0.86	0.85	269419.16	829.26	832.25	209996.28	72586688390	27.73
S-Shape	0.60	0.59	351780.82	846.87	849.86	271540.00	1.2375E+11	50.40
Exponential	0.67	0.65	435548.87	860.96	863.96	308061.65	1.89703E+11	43.70
Compound	0.67	0.65	435548.87	860.96	863.96	308061.65	1.89703E+11	43.70

The diagnostic tools may disclose the picture more clearly. 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. The value of R^2 (0.85) or $\bar{R}^2$ (0.84) are the highest for linear model in comparison with other models. Further, the model selection criteria AIC

Table 3. Parameter estimates of the models for wheat production in Dinajpur District.

Model	Parameter			
	a	b	c	d
Linear	-28216.68* SE=15289.77	10009.86** SE=784.69		
Logarithmic	l17666.92** SE=34416.71	100728.3 1** SE=12688.30		
Inverse	180362.09** SE=18883.84	-310008.99** SE=85359.07		
Quadratic	-4860.90 SE=’23594.60	6006.01* SE=3199.53	117.76 SE=91.29	
Cubic	-21002.55 SE=33579.49	11311.21 SE=8425.96	-266.56 SE=571.29	7.53 SE= 11.05
Power	828.42** SE=199.42	1.75** SE=0.08		
S-Shape	12.16** SE=0.16	-7.36** SE=0.73		
Exponential	7665.27** SE=2379.30	0.13** SE=0.01		
Compound	7665.27** SE=2379.30	1.14** SE=0.01		

(705.76), BIC (708.75) in favour of linear, but MAE (30813.89), MAE (30813.89), and RMSE (40172.69) in favour of cubic model .The important point here to noted that the value of R^2 *or* $\bar{R}^2$ are very low for the inverse and compound model and other tools are sufficiently large compared to linear model.

Table 4. Diagnostic of model selection for wheat production in Dinajpur District.

Model	Criteria							
	R^2	$\bar{R}^2$	RSME	AIC	BIC	MAE	MSE	MAPPE
Linear	0.85	0.84	41473.11	705.76	708.75	33965.07	1720019062	58.55
Logarithm	0.67	0.65	53541.63	722.62	725.61	40578.51	2866707003	61.47
Inverse	0.29	0.27	87103.54	754.74	757.73	68675.17	7587027229	902.90
Quadratic	0.85	0.84	40493.24	706.18	710.67	31977.61	1639702506	58.74
Cubic	0.85	0.83	40172.69	707.66	713.64	30813.89	1613845321	103.45
Power	0.93	0.92	48178.44	715.65	718.64	32576.65	2321162248	30.65
S-Shape	0.76	0.75	79171.95	748.43	751.43	51596.91	6268198134	81.07
Exponential	0.70	0.69	109829.02	770.04	773.03	62361.48	12062414181	43.41
Compound	0.70	0.69	109829.02	770.04	773.03	62361.48	12062414181	43.41

Although RMSE and MAE are small for cubic model but all the coefficients of cubic model insignificant. Therefore, the estimating growth rate of wheat production in Dinajpur linear model has been considered.

Table 5. Parameter estimates of the models of wheat production in Rajshahi District.

Model	Parameter			
	a	b	c	d
Linear	5034.68** SE=8989.82	6069.21 SE=461.37		
Logarithmic	-54913.49** SE=1 8905.93	63290.24** SE=6969.99		
Inverse	133212.64** SE=10991.40	-201781.64** SE=49683.53		
Quadratic	7636.16 SE=14238.85	5623.24** SE=1930.85	13.11 SE=55.09	
Cubic	-17931.69 SE=19284.79	14026.50** SE=4839.05	595.64** SE=328.09	11.93*** SE=6.34
Power	7319.83** SE=1319.35	0.94** SE=0.06		
S-Shape	11.74** SE=0.12	3.39** SE=0.57		
Exponential	21529.68** SE=3189.07	0.07** SE=0.007		
Compound	21529.68** SE=3189.07	1.08** SE=0.008		

Wheat production in Rajshahi: The estimated parameters of wheat production of Rajshahi in Bangladesh during 1971-72 to 2004-05 are presented in Table 5. It shows that all the coefficients of all the models are highly significant except quadratic model. The constant part of cubic model is found insignificant but linear, quadratic, and cubic is found significant at 1% level. It seems difficult at this stage to select the best model but looking at the diagnostic tools will be helpful.

The diagnostic tools are calculated and shown in Table 6. It appears from the Table that the values of R^2 (0.87) *or* $\overline{R}^2$ (0.86) are the highest and RMSE (23071.28), MSE (671.05), BIC (677.04), MAPPE (19159.50) are the lowest for cubic model.

Table 6. Diagnostic of model selection of wheat production in Rajshahi District.

Model	Criteria							
	R^2	$\overline{R}^2$	RSME	AIC	BIC	MAE	MSE	MAPPE
Linear	0.85	0.84	24459.90	670.91	673.91	19489.64	598287059.1	26.72
Logarithm	0.73	0.71	32802.82	690.28	693.27	27720.02	1076025150	51.56
Inverse	0.34	0.34	50698.90	719.02	722.01	42046.70	2570378623	93.89
Cubic	0.87	0.86	23071.28	671.05	677.04	19159.50	532284205.2	29.82
Quadratic	0.85	0.83	24436.83	672.85	677.34	19514.16	597158729.7	27.27
Power	0.86	0.85	24917.13	672.13	675.13	19551.25	620863647	24.72
S-Shape	0.53	0.51	47754.79	715.07	718.06	37018.34	2280520111	54.49
Exponential	0.78	0.77	36040.31	696.49	699.49	25379.93	1298904361	30.42
Compound	0.78	0.77	36040.31	696.49	699.49	25379.93	1298904361	30.42

So, for describing the growth pattern of wheat production of Rajshahi and making forecast with minimum error, the cubic model is the best.

Wheat production in Rangpur: The estimated parameters of wheat production of Rangpur in Bangladesh during 1971-72 to 2004-05 are presented in Table 7. The regression coefficients of all models are highly significant except quadratic model. All coefficients of cubic model are significant.

Table 7. Parameter estimates of the models of wheat production in Rangpur District

Model	Parameter			
	a	b	c	d
Linear	29544.89 SE=18189.76	5671.48** SE=933.52		
Logarithmic	-48692.34 SE=263 17.03	67762.80** SE=9702.22		
Inverse	156257.09** SE=12561.88	-244522.28** SE=56782.43		
Quadratic	10921.31 SE=29210.72	8105.49 SE=3961.l0	-18.40 SE=113.02	
Cubic	-92232.13** SE=30335.17	42019.06** SE=7611.87	-2522.90** SE=516.09	49.78** SE=9.98
Power	*2528.60** SE=94l.64	l.33** SE=0.13		
S-Shape	2528.60* SE941.64	1.33** SE=0.13		
Exponential	13712.81** SE=43 11.06	0.10** SE=0.0 1		
Compound	13712.81** SE=4311.06	1.10** SE=0.01		

The diagnostic tools are shown in Table 7. The values of R^2 (0.83) *or* $\bar{R}^2$ (0.81) are the highest and RMSE (42836.84), AIC (715.74), BIC (711.73), MAE (37895.85), MSE (2391732584), MAPPE (25.61) are the lowest for cubic model.

Table 8. Diagnostic of model selection of wheat production in Rangpur District.

Model	Criteria							
	R^2	$\bar{R}^2$	RSME	AIC	BIC	MAE	MSE	MAPPE
Linear	0.54	0.52	49491.49	717.43	720.42	41082.42	2449408408	39.09
Logarithm	0.61	0.59	45661.48	712.11	715.10	39721.04	2084971564	49.09
Inverse	0.37	0.35	57942.88	727.83	730.82	48277.18	3357377555	65.02
Cubic	0.83	0.81	42836.84	715.74	711.73	37895.85	2391732584	25.61
Quadratic	0.66	0.65	54215.17	725.44	729.93	45643.16	2939285017	35.61
Power	0.75	0.74	59779.07	729.89	732.88	43286.93	3573537535	55.86
S-Shape	0.52	0.50	58815.86	728.82	731.81	45888.24	3459306292	43.43
Exponential	0.56	0.55	88347.14	755.67	758.66	62367.25	7805218848	41.21
Compound	0.56	0.55	88347.14	755.67	758.66	62367.25	7805218848	41.21

Wheat production of Rangpur produced minimum error and cubic model is the best for forecasting. The aforesaid discussion, the fitness of various models to the time series of wheat production stated that not any particulars, but different models are appropriate for different regions in describing the growth patterns. The findings of the study revealed that selection of the best model for a particular region can sometimes be very confusing. However, the discussion recommends a best model for a particular district as well as for whole Bangladesh as shown in Table 9.

Forecasting

The best-fitted models for wheat production as used to make forecast with 95 percent confidence interval are presented in Tables 9. The prediction period extends from 2005/06 to 2009/10.

Table 9. Five years'95 percent forecast of wheat production (tons) in Bangladesh.

Model	Description	Forecast year				
		2005/06	2006/07	2007/08	2008/09	2009/10
Bangladesh (Quadratic)	Lower limit	985171.80	968876.57	946946.01	919265.37	885757.65
	Forecast	1554867.98	1556046.18	1554556.48	1550398.87	1543573.36
	Upper limit	2124564.16	2143215.80	2143215.80	2181532.37	2201389.07
Dinajpur (Linear)	Lower limit	219190.36	228719.15	238223.12	247702.69	257158.25
	Forecast	312118.81	322128.67	332138.54	342148.41	352158.28
	Upper limit	405047.25	415538.20	426053.96	436594.13	447158.31
Rajshahi (Cubic)	Lowerlimit	175609.70	184836.62	193503.89	201587.56	209110.51
	Forecast	239557.26	255109.51	271977.12	290231.73	309944.94
	Upper limit	303504.82	325382.39	350450.36	378875.90	410779.37
Rangpur (Cubic)	Lower limit	273188.07	308526.92	346364.31	386854.71	430226.66
	Forecast	374338.90	419683.00	470491.52	527070.09	589724.31
	Upper limit	475489.73	530839.09	594618.74	667285.46	749221.96

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 forecasted wheat production for Bangladesh as a whole and for Dinajpur, Rajshahi and Rangpur districts in the year of 2005/06 were 1.55, 0.31, 0.24, and 0.37 million tons, respectively, with a 95 percent confidence interval. The study showed that if the present growth rates remain same then the wheat production in Bangladesh as well as in Dinajpur, Rajshahi, and Rangpur districts would be 1.54, 0.35, 0.31, and 0.58 million tons in 2009/10.

Conclusion

The study showed that different models are suitable for different districts in producing wheat production. The model linear was found appropriate for Dinajpur District, while cubic model was appropriate for both Rajshahi and Rangpur districts. On the other hand, quadratic model was found appropriate for Bangladesh. It meant that the annual growth rates were significantly different from time to time for wheat production. Five-years' forecasts of wheat production in Bangladesh, Dinajpur, Rajshahi, and Rangpur districts in 2005/06 were 1.55, 0.31, 0.24, and 0.37 million tons, respectively. If the present growth rates continue, wheat production in Bangladesh, Dinajpur, Rajshahi, and Rangpur districts would be 1.54, 0.35, 0.31, and 0.58 million tons, respectively, in 2009/10.

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