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Journal of Applied and Advanced Research 2017, 2(1): 6–12
doi.: 10.21839/jaar.2017.v2i1.39
http://www.phoenixpub.org/journals/index.php/jaar
ISSN 2519-9412 / © 2017 Phoenix Research Publishers

Research Article – Agriculture

Growth and Variability of Major Food Crops Production in Khyber Pakhtunkhwa, Pakistan

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Abstract

The present study was undertaken to investigate the growth and variability in major food crops production of Khyber Pakhtunkhwa. The study was based on secondary data, covers a period of about 30 years i.e. starting from 1984-85 to 2013-14, Whereas, the growth models has been employed to fit the best growth model and Cuddy Della Vella Index was applied to find variability in major food crops production i.e. wheat, maize, sugarcane and rice. Based on the results of analyzed data, it was found that in major food crops (wheat, maize, sugarcane, rice) Production, the growth models i.e. Cubic growth model, power growth model, cubic growth model, cubic growth model respectively were found suitable, based on the R^2criteria and fitted trend line. After selecting best fitted model for each major food crop, the growth rate was calculated by using the selected fitted models which were found to be 10.97%, 8.00%, 45.31% and 1.19% respectively. Moreover, the variability for each major food crop production was found to be 1.53%, 1.23%, 0.44% and 0.79% respectively.

Key words: Parameter estimates, Accuracy Measures, Variability, Cuddy-Della Valle Index, Co-efficient of Variation

Introduction

Agriculture is the key sector of Pakistan's economy since it contributes 23.1 percent of the gross domestic product (GDP) and contribute 43.7% of the employed labor force of the country. Agriculture is the largest source of foreign exchange earnings and very important sector for the economic development of the country by supplying raw material to the industrial sector and providing market for the industrial products. The major food crops including wheat, maize, rice and sugarcane contribute about 25.6% in the value addition and 5.4% in the GDP of Pakistan.Khyber Pkhtunkhwa province is gifted by nature with immense potentialties for budding food crops, Relatively suitable land, favorable climatic surroundings and copious supply of farm labour. Food crops play a significant role in developing countries like pakistan by providing food security and saving the scarce foreign exchange to be spent on the import of wheat and rice etc. The cost-effective variables like sources of income, labour force employment and capital, marketing activities, consumption pattern, financing and credit, labour distribution, surpluses and returns are most strongly related with food crops output in Khyber pakhyunkhwa. A product on which the market of a section concentrates is the large amount of capital and labour is called staple product (Vogt and Dolan, 1984). There are two major harvest seasons that is Rabi Season in which sowing period starts from October and finish in May, while, the Kharif season starts from April and ends in October. The crops which are grown in Rabi and Kharif seasons are Mustard, wheat, tobacco, masoor, rapeseed, barley and gram are "Rabi" crops while jowar, bajra, mash, mong, maize, cotton, sugarcane and rice are "Kharif" crops.

Received: 01-01-2017; Accepted 23-01-2017; Published Online 07-02-2017

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The main food crops of Khyber Pakhtunkhwa province are sugarcane, wheat, rice and maize. Diverse varieties of these food grains are developed in different regions of the province as compared to barley, bajra and jowar which are not mature comprehensively. The most important rice varieties developed in Khyber Pakhtunkhwa are Basmati-385, JP-5, Sara Saila, and Dil rosh-97. The most impotant wheat varieties developed in Khyber Pakhtunkhwa are Fakhre- Sarhad, Auqab-200, Bakhtawar-92, Khyber-87, Haider-2002, Saleem-200 and Tatara. The five main varieties of maize such as Ghori, Babar, Jalal, Azam and Pahari are full-grown in Khyber Pakhtunkhwa. The major sugarcane varieties grown in Khyber Pakhtunkhwa are CP77-440, CP 51-52, CP65-357, SPF 238, HSF 240 ans SPF 242. Food-grain crops generally wheat, rice, maize and sugarcane are dissimilar in stipulations of price and production on the identical dimensionof land. Sen (1967) observed the variability phenomena and concluded that the agriculture produce was enlarged due to increased usage of purchased inputs and also caused expansion in the cultivation related to the marginal land and resources. Rao (1975) compared the variability in yield and area by arguing that variability in productivity was much greater than the variability in the corresponding area due to shifting growth components which was based on increasing area related to growth and also based on the increasing the productivity which automatically led towards the increased production variability as well. Mehra (1981) argued that due to wide spread adoption of modern seed-fertilizer as well as sophisticated technologies, since the mid period of 1960's, the change was found in the context of variability i.e. India's total food grain production were increased. Hazell (1982 and 1989) observed that due to their vast scope and adoption of modern prevailing technology, the variability in production of world cereal as well as Indian food grain were also been increased.

Material and Methods

The present study is conducted by using time series data with effect from 1984-85 to 2013-14 i.e. time series data of 30 years, to find growth and variability regarding major food crops including wheat, maize, sugarcane and ricein Khyber Pakhtunkhwa, Pakistan. The time series data were collected from secondary sources of various issues Crop Statistics, Crop Reporting Service of Khyber Pakhtunkhwa and were analyzed in Statistical Package SPSS version 22.

The study has been carried out by using different growth models including Linear growth model, Quadratic growth model, Cubic growth model, Power growth model, S-curve model, Logarithmic growth model, Exponential growth model, Compound growth model, Growth curve, Inverse curve, Logistic Curve to find out the best fitted model for production of major food crops of Khyber Pakhtunkhwa.By selecting the bestfitted growth model based on the criteria of $R^2$and fitted trend line to forecast the food crops production for onward ten years. The models used in the study are presented below for the purpose of clear understanding.

Growth models

i Linear Growth Model

Linear growth model is used for forecasting trend in production of major fruit crops. The model can be described as follows:

$$Y_t = \beta_0 + \beta_1 t + e_t \qquad ----(1.1)$$

Where, Y_t represents the production predicted at time t , t represents time index, β_0 is the intercept of the model, β_1 is the annual change in production and e_t is the error term of the model (Rimi *et. al*.2011).

ii Quadratic Growth Model

Quadratic growth model is used to check the trend patterns. The model can be described as follows:

$$Y_t = \beta_0 + \beta_1 t + \beta_2 t^2 + e_t \qquad -----(1.2)$$

Where, Y_t represents production predicted at time period t, t is the time index β_0 is the intercept, β_1 and β_2 represents annual change in production, e_t is the error term of the respective model (Finger, 2007).

iii Exponential Growth Model

Exponential growth model permits relationship in which the series increases (decreases) at increasing (decreasing) rate. The exponential trend model is described as follows:

$$Y_t = \beta_0 * \beta_1^t + e_t \qquad --------(1.3)$$

Where, Y_t represents predicted production; t is the time index, β_0 is the intercept of the model, β_1 is the respective annual change in production and e_t is the error term of the model (Pere, 2000).

iv Cubic Model

Cubic Model is defined by the equation

$$Y_t = \beta_0 + \beta_1 * t + \beta_2 * t^2 + \beta_3 * t^3 + e_t \qquad ----- (1.4)$$

Where, Y_t represents predicted production; t is the time index, β_0 is the intercept of the model, β_1, β_2 and β_3 is the respective annual change in production and e_t is the error term of the model (Wiktor and Travis, 1985).

v Power Growth Model (PGM)

Power growth model (PGM) can be written in equation form as

$$Y_t = \beta_0 * t^{\beta_1} + e_t \qquad ----- (1.5)$$

Where, Y_t represents production predicted at time period t, t is the time index β_0 is the intercept, β_1 represents annual change in production, $e_t$is the error term of the respective model(Rao*et al*. 1980).

vi Logarithmic Growth Model

Logarithmic growth model can be written in equation form as

$$Y_t = \beta_0 + \beta_1 * ln(t) + e_t \qquad ----(1.6)$$

Where, Y_t represents the production predicted at time t, t represents time index, β_0 is the intercept of the model, β_1 is the annual change in production and e_t is the error term of the model (Sagar, 1980).

vii Inverse Growth Model.

The Inverse growth model in the equation form can be written as follows:

$$Y_t = \beta_0 + \frac{\beta_1}{t} + e_t \qquad ----(1.7)$$

Where, Y_t represents the production predicted at time t, t represents time index, β_0 is the intercept of the model, β_1 is the annual change in production and e_t is the error term of the model (Rao*et. al*. 1980).

viii Compound Growth Model

Compound growth model is described in the equation form as follows:

$$Y_t = \beta_0 * {\beta_1}^t + e_t \qquad ------(1.8)$$

Where, Y_t represents the production predicted at time t, t represents time index, β_0 is the intercept of the model, β_1 is the annual change in production and e_t is the error term of the model (Wiktor and Travis, 1985).

To examine the extent of variability in the production of major food crops of Khyber Pakhtunkhwa, the Cuddy-Della Valle Index is used (Cuddy and Della Valle, 1978).

The instability in produce of major food crops can be measured in relative terms by using the Cuddy-Della Valle index (I) which is symbolically written as:

$$I = CV * \sqrt{1 - AdR^2} \qquad ------(1.6)$$

Where,

I = Instability index (in percent)

CV = Coefficient of variation (in percent), and

AdR= Coefficient of determination from time trend regression adjusted by the corresponding number of degrees of freedom.

Results and Discussions

1.1 Growth Model for Wheat Production

The growth analysis technique is employed to checkbest fitted trend model for wheat production in Khyber Pakhtunkhwa province of Pakistan by using SPSS Package. Among the growth models including linear growth model, Quadratic growth model, cubic growth model, compound growth model, exponential growth model, power growth model, S-Curve model, inverse trend model, growth model, logarithmic growth model, logistic growth model etc., the best fitted model on the basis of R^2 criteria and fitted trend line the cubic growth curve is found to be best fitted curve presented in Table-1 and Figure-1.

The parameter estimate of all selected models presented in Table-1 is found to be significant, except Quadratic growth model having $p \leq 0.05$. Also, cubic trend model is found to be the best suitable one among the studied trend models, on the basis of fitted trend curve and accuracy measures.

Figure-1 shows that the fitted line provides a good fit as it passes through majority of the data points. Moreover, based on the parameter estimates of best fitted growth model, the growth rate for wheat production is calculated to be 10.97% having significant contribution in wheat production over last 30-years.

2.1. Growth Model for Maize Production

The growth analysis for Maize production is performed to check the best fitted trend models among the described models. It has been found that the power growth model is the best fitted growth model on the basis of R^2 criteria and fitted trend line. Trend curve and its parameter estimates are given in Table-2 and Figure-2.

The parameter estimates of all the selected models presented in Table-2 are found to be significant at 5% level of significance. Also, the power growth model is found to be best suitable model among the studied models, on the basis of best fitted trend line and accuracy measures.

From Figure-2, it is depicted that the fitted line provides a good fit as it passes through majority of the data points. Moreover, growth rate is calculated to be 8.00% based on power growth model parameter estimates, which provides significant growth over 30-years.

3.1. Growth Model for Sugarcane Production

The growth analysis of sugarcane production is made after selecting best fitted model among the studied models; it has been found that exponential growth model is the best fitted model on the basis of R^2 criteria and fitted trend line. Trend curve and also its parameter estimates are presented in Table-3 and Figure-3.

From Table-3, it is showed that parameter estimates of all the selected models are found to be significant at 5% level of significance. Also, the cubic growth model is calculated to be best suitable model among the studied trend models, on the basis of accuracy measures and best fitted trend line.

Figure-3 shows that the fitted trend line provides good fit as compared to other selected models and it passes through majority of the data points. Furthermore, growth of sugarcane crop production is found to be 45.31% which shows higher growth rate as compared to other major food crops under study and it is encouraging factor for boosting economy of Pakistan.

4.1. Growth Model for Rice Production

The growth analysis of Rice crop production is performed after evaluating best fitted growth model firstly among the growth models under study. It has been found that the cubic trend model is the best fitted model on the basis of R^2 criteria and fitted trend line. Trend curve and its parameter estimates are given in Table-4 and Figure-4.

From Table-4, the parameter estimates of Quadratic and Cubic growth model is found to be significant and all others are found to be non-significant at 5% level of significance. Also, cubic growth model is found to be best suitable model among the studied growth models, on the basis of accuracy measures and best fitted line.

In Figure-4, the cubic model for rice crop production shows that the fitted line provides the best trend as it passes through majority of the data points. Moreover, the growth of the rice crop production over 30-years is calculated to be 1.19% which is found to be very low as compared to other major crops under study.

5.1. Variability of Major Food Crops Production in Khyber Pakhtunkhwa

The variability of major food crops production has pivotal role for sustainable production as well as for the economy of the country. Therefore, an effort has been made to estimate the relative variability in major fruits production presented in Table-5.

The variability in production of major food crops of Khyber Pakhtunkhwa is estimated with effect from period 1984-85 to 2013-14. It is observed that among all the four major food crops production i.e. wheat, maize, sugarcane, rice in which the wheat crop production possesses high variability (1.53%) whereas; the sugarcane crop production has the least variability (0.44%).

Table 1. Model Summary and Parameter Estimates for Wheat Production.

Equation	Model Summary					Parameter Estimates			
	R Square	F	df1	df2	Sig.	Constant	b1	b2	b3
Linear	0.192	6.67	1	28	0.015	989.972	6.876		
Logarithmic	0.251	9.369	1	28	0.005	894.331	81.259		
Inverse	0.235	8.592	1	28	0.007	1142.697	-346.515		
Quadratic	0.194	3.25	2	27	0.054	976.362	9.428	-0.082	
Cubic	0.511	9.07	3	26	0	729.239	97.917	-7.103	0.151
Compound	0.184	6.327	1	28	0.018	984.863	1.006		
Power	0.247	9.172	1	28	0.005	898.579	0.077		
S	0.239	8.815	1	28	0.006	7.036	-0.333		
Growth	0.184	6.327	1	28	0.018	6.893	0.006		
Exponential	0.184	6.327	1	28	0.018	984.863	0.006		
Logistic	0.184	6.327	1	28	0.018	0.001	0.994		

Table 2. Model Summary and Parameter Estimates for Maize Production

Equation	Model Summary					Parameter Estimates			
	R Square	F	df1	df2	Sig.	Constant	b1	b2	b3
Linear	0.553	34.692	1	28	0	673.195	8.226		
Logarithmic	0.744	81.401	1	28	0	554.971	98.742		
Inverse	0.617	45.053	1	28	0	853.451	-396.129		
Quadratic	0.743	39.039	2	27	0	570.169	27.544	-0.623	
Cubic	0.768	28.731	3	26	0	521.035	45.137	-2.019	0.03
Compound	0.543	33.276	1	28	0	671.271	1.011		
Power	0.772	95.033	1	28	0	568.868	0.134		
S	0.686	61.147	1	28	0	6.752	-0.557		
Growth	0.543	33.276	1	28	0	6.509	0.011		
Exponential	0.543	33.276	1	28	0	671.271	0.011		
Logistic	0.543	33.276	1	28	0	0.001	0.989		

Figure 1. Cubic Curve Plot for Wheat Production

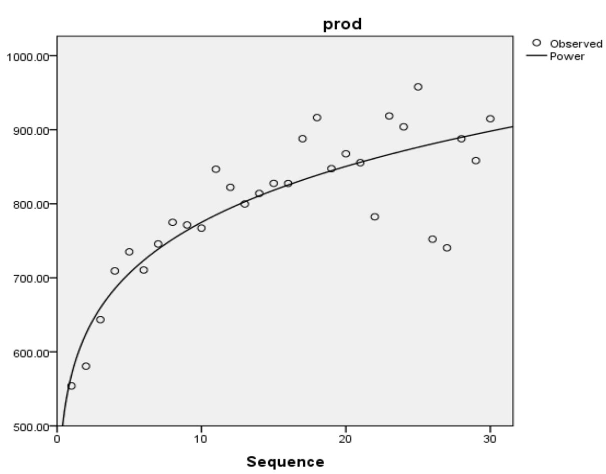

Figure 2. Power Curve Plot for Maize Crop Production

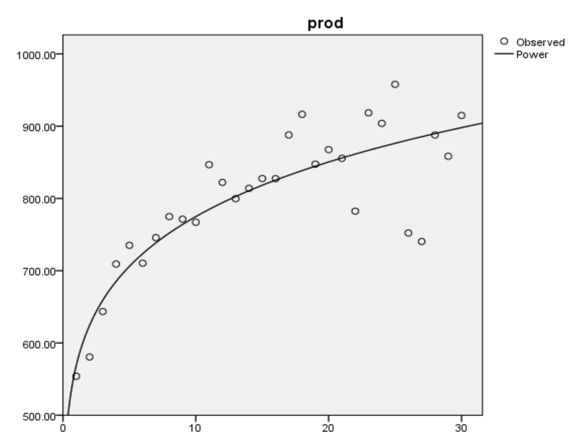

Table 3. Model Summary and Parameter Estimates for Sugarcane Production

Equation	Model Summary					Parameter Estimates			
	R Square	F	df1	df2	Sig.	Constant	b1	b2	b3
Linear	0.353	15.262	1	28	0.001	4095.121	28.219		
Logarithmic	0.56	35.611	1	28	0	3616.759	367.977		
Inverse	0.485	26.334	1	28	0	4733.425	-1508.75		
Quadratic	0.591	19.467	2	27	0	3599.58	121.132	-2.997	
Cubic	0.716	21.801	3	26	0	3129.472	289.467	-16.353	0.287
Compound	0.352	15.211	1	28	0.001	4077.031	1.007		
Power	0.575	37.882	1	28	0	3637.385	0.087		
S	0.509	29.011	1	28	0	8.462	-0.359		
Growth	0.352	15.211	1	28	0.001	8.313	0.007		
Exponential	0.352	15.211	1	28	0.001	4077.031	0.007		
Logistic	0.352	15.211	1	28	0.001	0	0.993		

Table 4. Model Summary and Parameter Estimates of Rice Production

Equation	Model Summary					Parameter Estimates			
	R Square	F	df1	df2	Sig.	Constant	b1	b2	b3
Linear	0.053	1.574	1	28	0.22	122.689	-0.327		
Logarithmic	0.003	0.07	1	28	0.793	119.442	-0.735		
Inverse	0.002	0.068	1	28	0.796	118.039	-3.193		
Quadratic	0.459	11.471	2	27	0	103.334	3.302	-0.117	
Cubic	0.524	9.523	3	26	0	113.397	-0.302	0.169	-0.006
Compound	0.07	2.107	1	28	0.158	123.398	0.997		
Power	0.008	0.213	1	28	0.648	120.402	-0.012		
S	0	0.013	1	28	0.91	4.763	-0.013		
Growth	0.07	2.107	1	28	0.158	4.815	-0.003		
Exponential	0.07	2.107	1	28	0.158	123.398	-0.003		
Logistic	0.07	2.107	1	28	0.158	0.008	1.003		

Figure 3. Cubic Curve Plot for Sugarcane Production

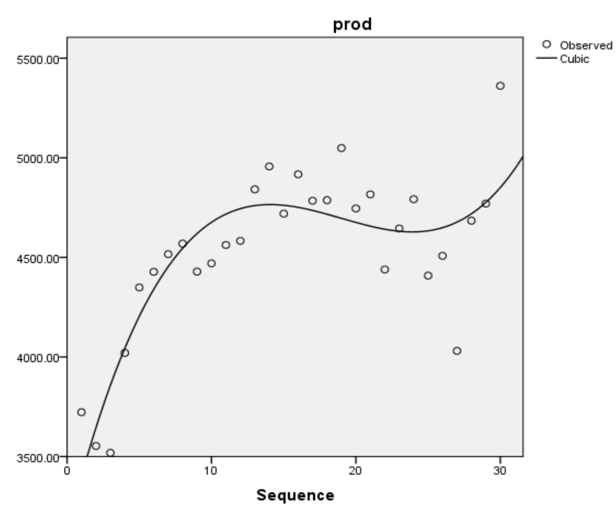

Figure 4. Cubic Curve Plot for Rice Production

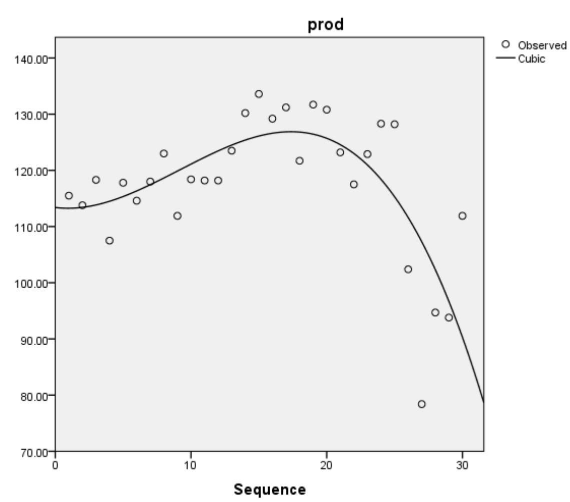

Table 5. Variability Index for Major Food Crops of Khyber Pakhtunkhwa

Food Crop	CV (%)	AdR^2	Variability Index $(I) = CV * \sqrt{1 - AdR^2}$
Wheat	12.586	0.985383	1.53
Maize	12.158	0.989827	1.23
Sugarcane	9.2278	0.997722	0.44
Rice	10.626	0.994462	0.79

Conclusions and Recommendations

From the analyzed data of the each selected major food crop i.e. wheat, maize, sugarcane and rice, the best model for each was calculated on the basis of best fitted trend line and accuracy measures. The best fitted model for major food crop was cubic growth model, power growth model, cubic growth model and cubic growth model respectively. Based on the parameter estimate of best selected model of each major food crop, the growth rates were calculated and found to be 10.97%, 8.00%, 45.31% and 1.19% respectively. Moreover, the variability measure for wheat crop production was recorded higher i.e. 1.53%, as compared to other food crops under study and sugarcane possess least variability i.e. 0.44% which was may be due to fluctuating crop acreage, area and productivity. Also, variability measure for maize and rice were calculated to be 1.23% and 0.44% respectively. Therefore, it can be suggested that these selected models could be used for evaluating growth rate of major food crops production and hence useful for researchers, business men, policy makers for planning their resources as well as decision making regarding food crops production in Khyber Pakhtunkhwa.

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