Wheat Production Under Alternative Production Functions

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INTRODUCTION

In an earlier study [1, pp. 407-415] it was assumed that a linear production function would be the best to depict the relationship between wheat production and explanatory variables in the Punjab. After a careful scrutiny, four of the explanatory variables, viz., area under Mexican Wheat varieties, area under local wheat, fertilizer application and rainfall, were employed to explain variations in wheat production. As this linear relationship gave a good fit, it was claimed that the equations, derived from 1967-68 to 1971-72 output and input data, can be useful in forecasting wheat production in the Punjab for future years well in advance of actual wheat harvests and, in fact, a forecast of wheat production in the Punjab for 1973-74 was published [2, pp. 106-112], based on the findings of that model.

Whether the linear production function related the dependent and independent variables in the best possible manner was not tested. The results of our analysis in the present paper indicated that the re-specification of the relationship will be of little use.[1] In addition, in an earlier model the rainfall relevant to wheat production was defined as the total rainfall during the months of November-January of each wheat season. Publication of the article containing that model elicited suggestions that use of seven-month rainfall from July to January (instead of three-month rainfall used in the model) might improve the results of the model. Accordingly, it was decided to test that model using

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1. The linearity assumption was checked using two other forms of production functions, that is, CES (Constant Elasticity of Substitution) and Cobb Douglas (log linear). The application of Kmenta's linear transformation of CES [3, pp. 180-89] and Cobb Dauglas production function yielded unsatisfactory results with very low R^2 values compared to the linear form. Hence, the results of the CES and Cobb Dauglas production functions are not reported here.

seven-month rainfall. Besides, we will also present the results based on the deviations of actual level of rainfall from the normal level defined for both three-month and seven-month periods.

Wheat Production with Alternative Definitions of Rainfall

Having tested the linearity assumption we proceed to employ the linear model for explaining wheat production variations under alternative definitions of rainfall. To accomplish this, rainfall was alternatively defined as the (1) sum of actual amount of rainfall during November-January period, (2) sum of actual amount of rainfall during November-January period, (3) deviations of actual rainfall from normal during Nov.-January period, and (4) deviations of actual from normal rainfall during July-January period of each wheat season; and separate regressions were based on each of the rainfall definitions with other inputs and output defined as before. The results of these regressions are presented in Table I.

On the basis of the R^2 values in Table I, it would seem that the three-month absolute level of rainfall in the *Barani* areas and seven-month absolute level of rainfall in the irrigated areas, along with the constancy of other explanatory variables, best explains the variations in wheat production. The two equations, however, could be rejected for they show a negative relationship of wheat output with rainfall which is absurd and contrary to *a priori* expectation. In addition, a closer look at the values of R^2 would reveal that any of the equations in Table I would provide for as good an approximation as the above two equations because the differences in R^2 values are not very significant. Ignoring R^2 values, therefore, the best equations for forecasting purposes would be the ones which satisfy an *a priori* expectation of positive relationship between rainfall and wheat production. It is here that the deviations of actual rainfall from normal become important.

Equations based on three-month deviations could be excluded from the choice of appropriate equations for either of the above reasons. In the *Barani* areas, the three-month deviations show an insignificant relationship with fertilizer applications and are therefore, inappropriate. We thus are left with the choice of equations using seven-month rainfall deviations and we consider them as the best equations for the purpose of forecasting wheat production. It may be stated that the two selected equations have almost the same values of R^2, have positive relationship with wheat production, and are statistically significant.

Alternative Wheat Production Forecast for 1973-74

In an earlier note [2, pp. 106-112] wheat production in the punjab for 1973-74 was predicted to be 6 million tons. This forecast, however, was based on three-month absolute level of rainfall as one of the explanatory variables. As has been shown in this paper, three month absolute rainfall is not an appropriate variable for wheat production. An alternative forecast of wheat production for 1973-74 based on seven-month deviations of actual rainfall from normal is presented here replacing our earlier forecast figures for the Punjab. While Appendix A provides basis for detailed calculations of the forecast, it is noticeable that our revised equations predicted 6.8 million tons of wheat in the Punjab. This figure compares favourably with the government target of 6.5

Table I

Results of the Linear Production Functions with Alternative Definitions of Rainfall

Regression Coefficients	Absolute level of Rainfall during		Actual Rainfall Deviations from Normal during	
	Nov.-Jan.	July-January	Nov.-January	July-Jan.
I. *Barani District*				
a	—16.02	3.27	—21.04	—14.48
B_1	0.50 (8.95)	0.35 (4.49)	0.45 (9.16)	0.44 (7.23)
B_2	0.16 (7.08)	0.17 (5.12)	0.18 (8.04)	0.18 (5.96)
B_3	1.87 (2.57)	0.02 (2.89)	0.02 (0.01)	0.03 (3.73)
B_4	—0.95 (—0.49)	—0.99 (—3.25)	6.03 (4.20)	2.03 (2.31)
R^2	0.94	0.87	0.92	0.88
F. Ratio	63.99	31.29	53.90	34.21
D.W. Statistic	2.63	1.39	2.10	1.26
II. *Irrigated Districts*				
a	—118.62	—79.58	—130.59	—115.37
B_1	0.59 (12.34)	0.65 (17.69)	0.59 (13.08)	0.58 (13.71)
B_2	0.65 (16.94)	0.66 (23.04)	0.65 (16.82)	0.62 (17.30)
B_3	0.02 (6.33)	0.01 (5.83)	0.02 (6.62)	0.02 (7.18)
B_4	—7.93 (—2.16)	—3.90 (—6.27)	—1.58 (—0.97)	4.89 (1.36)
R^2	0.95	0.97	0.95	0.95
F. Ratio	383.17	659.45	380.85	448.74
D.W. Statistic	1.73	1.59	1.81	1.80

Figures in parentheses represent "t" Statistics.

million tons of wheat during the same year. Our forecast also confirms the widely publicised claim of the government that the actual wheat production exceeded the fixed target for 1973-74.

CONCLUSION

In an earlier paper, linearity of wheat production to explanatory variables was assumed. The present paper's investigations confirm that the relationship between wheat production and the explanatory variables is necessarily of the linear type. Whereas in the earlier paper, three-month absolute level of rainfall (November-January) was assumed to be the appropriate rainfall for wheat production, our statistical verifications in this paper with alternative definitions of rainfall fail to confirm that assumption. Instead, we found that seven-month (July-January) actual rainfall deviations from normal are more appropriate for explaining wheat production variations. Using seven-month deviations of rainfall, the earlier forecast was replaced by a revised forecast of wheat production which came to 6.8 million tons of wheat during 1973-74. This compares favourably with the government target of 6.5 million tons of wheat in the Punjab and confirms that the actual wheat production was in excess of the fixed target for 1973-74.

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Appendix A

Determination of Wheat Production in the Punjab for 1973-74

Districts	Products of Coefficients and values of Explanatory variables					Wheat Output 1973—74
	L	B_1X_1	B_2X_2	B_3X_3	B_4X_4	
A. *Barani Areas*						
Campbellpur	— 14.48	27.72	107.44	9.39	17.66	147.73
Rawalpindi	— 14.48	25.96	49.30	12.42	6.90	80.10
Jhelum	— 14.48	17.60	60.86	5.43	26.04	95.45
Mianwali	— 14.48	118.80	49.47	71.34	2.94	228.07
B. *Irrigated Areas*						
Gujrat	— 115.37	221.56	121.52	38.10	95.84	361.65
Sargodha	— 115.37	262.16	207.08	105.88	3.91	455.84
Lyallpur	— 115.37	512.14	16.74	235.48	40.24	689.23
Jhang	— 115.37	278.68	78.12	112.48	27.97	390.88
Sialkot	— 115.37	257.52	156.86	84.88	76.24	460.13
Gujranwala	— 115.37	359.02	29.76	70.40	83.23	427.04
Sheikhupura	— 115.37	265.06	66.96	62.92	28.22	307.79
Lahore	— 115.37	286.52	26.04	88.90	32.86	318.95
Sahiwal	— 115.37	470.96	96.72	202.76	36.09	691.19
Multan	— 115.37	483.14	233.74	303.02	20.93	925.46
Muzaffargarh	— 115.37	96.88	372.00	86.48	5.13	445.10
D.G. Khan	— 115.37	19.72	197.16	29.40	2.74	133.65
Bahawalpur	— 115.37	40.60	148.80	91.64	55.79	221.46
Bahawalnagar	— 115.37	34.22	217.62	36.44	15.84	188.75
Rahimyar Khan	— 115.37	94.54	169.26	65.42	0.88	214.73
Total (A+B)	— 1788.47	3881.78	2405.45	1712.78	571.63	6783.20