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Economic Models for Acreage Response of Punjab Wheat

G. S. KAINTH*

Under-nutrition and malnutrition are the twin problems of world's dietry habits. The people in underdeveloped areas scramble for food to stay alive. They are perpetually tired, weak and vulnerable to diseases. Since their undernourishment being from their birth, it creates permanently depressing and irremediable effects on the population. It seems rather paradoxical that even though more than two-thirds of our population is engaged in farming and more than three-fourths of our cropped area is under foodgrains, our food supply still falls far short of our requirements. This points to need for raising productivity so as to provide a minimum quantity of food. Further, in order to industrialize the economy, we need a substantial improvement in our nourishment, efficiency, and raw materials for the industry. This depends on the rate of improvement in our food and agricultural production. There is, therefore, the need to frame and implement policies which lead to substantial expansion of food and agricultural production. The whole fabric of our past and present policies in this direction cannot be judiciously evaluated without an analysis of the farmer's response to economic and non-economic variables. The subject of farmer's responsiveness to economic variables has gained importance during the past few decades in both underdeveloped and developed countries. Developing economies need to understand the supply phenomena in order to implement policies for raising the output to a level which can provide for adequate human nutritions for the growing population and also to promote general economic development. Even in developed countries understanding of supply phenomena is of crucial importance for controlling surplus, for raising the farm incomes, and resource productivity. The present study attempts to examine the acreage response of wheat to economic and non-economic factors in Indian Punjab under changing farm technology.

Design of Study

The study pertains to Punjab–one of the most agriculturally advanced state of Indian union. However, within the State there exists acute variation in agricultural development across different districts. To capture the varying magnitude of development, different districts

* *Department of Economics and Sociology, Punjab Agricultural University, Ludhiana–* 141004 (*India*).

of the state were grouped into two sub-groups on the basis of wheat productivity for the year 1979-80 through 1981-82. Ludhiana district was selected to represent relatively developed districts. The principal source of secondary data was Statistical Abstract of Punjab– an official publication of Economic and Statistical organisation of Punjab Government. The time reference of the study was 1961–62 through 1982–83. However, district–wise data were not available for some of the parameters for 1961–62 Therefore, time reference of the disaggregated (district-wise) analysis was 1965-66 through 1982–83.

Theoretical Framework

The nature and the extent of a farmer's response to changes in prices, remaina widely debated and controversial issue. One School is of the view that peasants in the UDC (Under-Developed Countries) are not responsive to change in the relative prices and lack motivation. The agricultural supply function has a price elasticity near zero. B. D. Giles doubts whether the model of profit maximization is applicable to agriculture. To quote him "there is not a little evidence to show that, of the output which are technically possible, the farmers will produce a collection very like that which would yield the greatest profit, although, in fact, he may never operate at the point of equilibrium."

The lack of responsiveness of agricultural production to change in price is attributed to a number of factors which are operative in agricultural production. The historic explanation for the disappointing response of the farmers to price incentive is that farming is a way of life. A great part of the production is meant for the self–consumption of the farmers. Under a subsistence form of agriculture, the individual farmers will not be concerned with prices and price relationships, since the production will be consumed in the household. While it is true that a great part of farm production is consumed by households, and that part of the produce will be price irresponsive, the portion of the area or the produce meant for the market can reasonably be expected to respond to the price change. On this basis, it can be said that the farm production response to price may be low but it cannot be nothing, as in no country the whole of the produce is consumed by farm producers. The farmers produce certain crops purely meant for the market and it is expected that in case of these cash crops, the profit motivation must be effective and changes in the relative prices of food crops and the cash crops ought to influence the decision of the farmers in allocating the areas and other resources to the production of these two types of crops. We can simply expect that the food crops, which are largely for the self-consumption of farmers, will be less responsive to the price as compared to the responsiveness of the crops, but we cannot preclude the role of market mechanism even in case of the food crops. We can only expect a distinction in the degree of responsiveness of these two types of crops.

Another explanation given for the lack of responsiveness of aggregate agricultural production to price change is that agricultural costs are composed largely of fixed costs. The production of farm inputs which the farmers purchase is very small and a large part of the resources comes from within the family and the farm. The family labour, livestock, agri-

cultural machinery, farm buildings and agricultural land assume the character of fixed costs and these fixed factors are not adoptable for use in the non-farm sector, so that they will continue to be used in agriculture even if the prices fall sharply. Only the variable factors which constitute a small proportion of the total farm inputs can be dismissed from use, that is, if the price does not cover the variable costs, aggregate agricultural production can be less price elastic. But here also we cannot exclude the role of the price mechanism in the decisions of farmers to use the variable factors, even if they constitute small proportion in the total farm inputs in the process of agricultural production. If the farmers cannot dismiss the fixed factors from use, they are likely to dispense with the variable factors from employment. Thus, we can say that the response of agricultural production may be low, but there is no reason why it ought to be nothing.

In a developing agriculture, the proportion of variable factors in the total farm inputs is low. But as farming is carried along commercial lines and as the opportunity for employment of farm labour increase in the non-farm seetor the importance of the fixed factor goes on declining. In developed agriculture, the proportion of the variable factor is high, so that the ability for adjustment of agricultural production to the price change is also high. It is therefore, suggested that if farms were organised on a corporate basis and if hired labour were used instead of family labour, the producers would have behaved just like industrial producers.

We may now examine another commonly held belief that the agricultural supply curve is backward bending. The explanation given to account for the perversity of the response of aggregate output to price is that the farmer's requirement for money income is fixed, so that they are required to produce and sell more when agricultural prices fall, and less when agricultural prices tend to rise. On this presumption, D R. Khatkhate and N.A. Khan have claimed that in India the farmers have a backward bending supply curve of the marketed surplus of agricultural produce, it also applied to aggregate agricultural production. To quote: "The economic organisation is such that within Limits, a fall in prices stimulates supply of farm products, and a rise in prices check it. We get in agriculture what is known as inverted supply curves." This perversity in the response of aggregate agricultural production is also believed to exist in other countries, at least in the developing countries, where a large part of the produce is meant for the self-consumption of the farmers. Thus J.H. Bocke of Indonesia believes in the backward bending supply curve of agricultural production. All these economists who have advanced the case of the perversity in the response of the farmers have in their minds what can be called 'target income'. They argue that the farmers have a fixed money obligation to pay rent, debt and interest thereon, to purchase cloth and other non-farm products of their requirement.

But there seems to be no reason to assume why the money requirement should be fixed. In a dynamic economy the demand for money income is always increasing. In a developing country where the level of per capita income in agriculture is so low that there are always

unsatisfied wants for bulk of the farmers, so that the marginal utility of income is not expected to be so low, the negative income effect of the improvement of the agricultural terms of trade would outweigh the positive substitution effect. The demand for money income is high in the agricultural sector, even for acquiring traditional forms of wealth, such as purchasing land, gold and other precious metals. In a dynamic economy, the demand for agricultural products is rapidly increasing, providing profitable opportunity of investment in agriculture. The farmer's demand for capital expenditure such as on the creation of irrigation works, fertiliser and land improvement can also be reasonably expected to increase. Besides, the demand for durable consumer goods such as bicycles, sewing machines, transistors will also be expected to increase due to the demonstration effect[2] of urban civilization, which will induce farmers to produce and sell more to acquire more money income. It will be wrong to assume that there is no change in the habits of the farmers. The contact with urban civilization through development of transport facilities, electrification and eduction will cause a disequilibrium in the desired and existing level and pattern of consumption in the rural population and may induce them to produce more and sell more.

Mathematical Recapitulation

The farmers face a number of constraints while making production decisions in response to changes in the economic environment in response to various economic stimuli. The farmer allocates his land to different crops, depending upon his expected revenue from different crops. Assuming that the input costs are either the same or more uniformly distributed, over time for different crop, the expected revenue depends upon the expected price. Uuder such conditions, the adjustment lagged model is considered appropriate for measuring the farmer's response behaviour. In recent years, a considerable body of literature has developed in the area of distributed lagged–model. In this study, we have chosen the Nerlovian adjustment lagged model. The long run supply A_t^* is assumed, in the Nerlovian framewok, to be related to P_t (the price) in a simple linear manner:

$$\overset{*}{A}_t = a + b\ P_{t-1} + U_t \quad \ldots \quad (1)$$

Variations in $\overset{*}{A}_t$ is connected by variations in A_t observed or actual supply by assuming the following relationship between the actual and long run desired level of supply.

$$A_t - A_{t-1} = V\ (\overset{*}{A}_t - A_{t-1}) \qquad (2)$$

The current supply then is:

$$A_t = A_{t-1} + V\ (\overset{*}{A}_t - A_{t-1}) \quad \ldots \quad (3)$$

V is coefficient of adjustment The forces which cause the difference the short run and long run elasticities of supply will also determine V. The first equation is a behavioural

relationship, stating that the desired acreage under the crop studied depends upon the relative farm prices in the preceeding year. The second equation is the partial area adjustment equation in which 'V' is the coefficient of adjustment. The value of the V coefficient lies between 0 and 1 and is based on Hick's elasticity of expectations. The farmers, it is hypothesized, are able to change the acreage of a crop in any year extent of the fraction 'V' of the difference between the acreage they will like to sow and the acreage actually sown in the preceding year. 'V' therefore, is an indication of how fast the farmers are adjusting themselves to their expectations. A value of V close to zero, would mean that farmers are very slowly adjusting themselves to the changing prices, yield etc. A value of V, close to unity, would mean that the farmers are instantaneously adjusting themeselves to the changing level of prices, yield etc.

Now by substituting the value of A_t^* in equation 2, we get:

$$A_t - A_{t-1} = V(a + b P_{t-1} + U_{t-1} - A_{t-1})$$
$$A_t - A_{t-1} = aV + bV P_{t-1} + V U_t - VA_{t-1}$$
$$A_t = aV + bV P_{t-1} + VU_t + A_{t-1} - VA_{t-1}$$
$$= aV + bV P_{t-1} + VU_t + (1-V) A_{t-1}$$
$$A_t = A + B P_{t-1} + CA_{t-1} + W_t \quad \ldots \quad (4)$$

Where $A = aV$, $B = bv + C = (1-V)$, and $W_t = VU_t$

Equation 4 is the computational equation the parameters of which are estimated by the least squares method. The reduced form would remain basically the same even if we include more independent variables than the one included in equation 4. Besides accounting for 'lags' that occur in farmer's adjustment behaviour, the model postulated above also helps in estimation of both the short run and long run supply elasticities.

Using the adjustment lag model as the basic frame of analysis, the response relationship in the study were estimated with the help of following equation:

$$A_t = b_0 + b_1 A_{t-1} + b_2 NI_{t-1} + b_3 VP_t + b_4 VY_t + b_5 RP_{t-1}$$

The specification of the various variables used for estimating supply response of wheat acreage are discussed below:

A_t: Acreage under wheat (in thousand hectare) crop during 't' period is the dependent variable.

A_{t-1}: Acreage under wheat lagged by one year.

NI_{t-1}: Net wheat area irrigated as a per cent of net wheat area sown lagged by one year.

RP_{t-1}: Relative profitability measured in terms of relative gross return per hectare lagged by one year. Relative gross return of wheat with respect to competing crop was estimated as below.

$$RP_{t-1} = \frac{\text{Per hectare yield X Harvest Price of wheat}}{\text{Per hectare yield X Harvest Price of Competing crop.}}$$

VP: Variability in prices to measure the price risks and is defined as Coefficient of variation in the series of the previous three year preceeding the year of decision.

VY: Variability in yields to measure the yield risks and is defined as coefficient of variation in the series of the previous three year preceeding the year of decision.

Both linear and log-linear form of the functions were tried. Regression were run for each of the three regions separately. The disaggregated results provide better understanding of the factors which influence farmer's production decisions.

Results and Interpretations

It was observed from the zero-order correlation matrix (Annex I) that there was high correlation among some of the explanatory variables, that is, there occured the problem of multicollinearity. The lagged dependent variable A_{t-1} showed the highest correlation with the net wheat area irrigated in the preceeding year (NI_{t-1}) among all the three region considered and also with the variability in the yield. Similarly net wheat are irrigated in the preceeding years was found to be very highly correlated with the variability in yield. Therefore, it was decided to computerise for the regression analysis for different possible combinations (considering part of the variable) in order to find out significant variable and most appropriate regression model.

The explanatory power of all the equations was found to be highly satisfactory because the value of coefficient of determination corrected for degree of freedom ($\bar{R}^2$) is more than 0.95 in most of the cases and is never below 0.86. The computed Durbin Watson statistic indicate absence of auto-correlation in most of the cases.

The Delayed Adjustment

The coefficient lagged acreage was found to be highly significant (at 0.01 level of significance) in the selected districts, namely, Ludhiana and Amritsar, as well as for the state as a whole. Its large value generally indicates a very slow adjustment on the farmer. It almost takes 13 to 20 years for 95 per cent of the effect of the price change to be realized in study area. Thus various techno-institutional and subjective factors seem to influence a great deal in decision making of the farmer for the wheat crop in Punjab.

Irrigation

With the expansion of the irrigation facilities, the area under wheat has tendered to increase over all the regions of the State, as shown by the positive coefficients with respect to this variable. However, individual regions differs in extent of impact of this variable on the acreage under wheat has been found to be positive and non-significant. The elasticity coefficient with respect to Amritsar and Ludhiana districts were worked out at 0.9731 and 2 2844 respectively and were significant at 0.01 level. The positive acreage irrigation response in the State of Punjab points to the fact that the farmers will shift to wheat crop if irrigation facilities are improved.

Risk Vis-A-Vis Farmer's Acreage Decision

Agriculture production is generally subjected to two major sources of risk, one arising from variation in prices, and the others in yield. Fluctuation in prices reflect conditions of demand and supply including uncertainties and imperfections in marketing systems. Variability in yield, on the other hand, are caused by weather conditions as the case of most of the cereal crops in India or by changes in production technology. The relative incidence of these risks may differ among individual crops and regions. Both the types of risks were incorporated in the model and the results of the regression are presented in Table 1 to 3 for Punjab State, Ludhiana district and Amritsar district respectively. The available estimates reveals that the coefficients of price risk on wheat area is negative and significant for Punjab State as a whole, while for the individual districts of Ludhiana and Amritsar it is negative and very weak (statistically non-significant). None of the equation fitted includes the variable. The same is true for the yield risk variables in the selected districts as well as the state as a whole. This variables has excercised relatively strong (statistically significant) deterent influence on acreage under the wheat crop. Thus the results indicates that the response of wheat has been more constant with economic theory which suggests negative relationship between risk and crop acreage. The deterent impact of risk either of yield or prices will point to the need of reducing the occurrence of such risks. In order to maintain the demand level of acreage and production of wheat, farmers will have to be assured of not only remunerative and stable prices but also of good and stable yield. Appropriate policy will therefore, need to have focus on:

(1) favourable pricing and marketing conditions.

(2)Technological improvements like varietal inputs, pest and disease controls etc.

Relative Profitability

The impact of the economic incentives on the wheat acreage has been found to be highy significant as is evident from the significant positive impact of relative profitability on wheat acreage. This suggests that additional income from the crop in the proceeding year has generally led to higher investment in the acreage of wheat crop in all the regions under study. It may be because that the suitable agro-economic conditions prevail for the successful propagation of the HYVs and hence additional investment is profitable. This in a way suggests that to the producer the growing of competing crops mainly for family consumption are of little importance. The farmers would generally like to meet his subsistence requirement at his own farm and feel secured. An excess production over subsistence requirements in a good year of the competing crop is generally saved for future consumption rather than sold out.

Conclusion

To test the hypothesis relating to the factors influencing the farmer's acreage allocation Nerlovian adjustment lag model has been used. The result of the analysis reveals that in the process of making the area decisions for wheat cultivation, the magnitude of the area

held in the preceding year has proved to be the most significant factor. Its main cause, as is evident from the general psychology of the farmers in the State, is that they follow the tradition in making decisions for raising different crops. They do not easily decide to reduce the area under the crop in comparison with the area they sowed in the preceding year. In this connection, their own requirements of food, ignorance about determining the appropriate cropping pattern owing to illiteracy and other traditional and social standards adopted by the farmers and the lack of suitable competing crops are the possible causes. The value of the Nerlovian coefficient of adjustment indicates a very slow adjustment on the part of the farmers. It almost takes 12 to 20 years for 95 per cent of the price change to be realised in the study area. Thus various techno-institutional and subjective factors seem to influence a great deal the decision-making of the farmers in Punjab regarding the wheat acreage. The positive acreage irrigation response in the State of Punjab points to the facts that farmers will shift to wheat crop if irrigation are improved.

The results obtained in this study lead to important implications that seem to be relevant from the point of view of pol'cy formulation. First, the varietal improvements in the wheat crop and the adoption of the varieties by the farmers having comparative advantages (technological, institutional and others) will be important for maintaining production at the desired levels. Second, the price and risk factors will need to be taken care of by appropriate measures in order to provide the necessary incentives to the producers; these policies must indeed go hand in hand with policies related to production technology. Thirdly, the results of the study indicate a positive response of land resources allocation to prices. This means that the farmers can find it possiable to make adjustment of the acreage allocation under wheat through the manipulation of relative prices of wheat and substitute crops. In order to bring about an effective adjustment in acreage allocation, the support prices for various crops must be announced well before the sowing season and the prices, thus announced, should carry a long-run guarantee. This policy will not only enable the farmers to place their production programmes better but might also help to correct the inter-commodity imbalance to some extent.

Table 1
Structural Coefficients of Acreage Response of Wheat in Nepal
(1961–62 through 1982–83)

Constant	A_{t-1}	NI_{t-1}	Regression Coefficients on VP	Regression Coefficients on VY	RP_{t-1}	$\bar{R}^2$	DW
			Linear Model				
186.53	0.9698***	—	-7.2300*	—	—	0.9648	2.20
(1.9505)	(22.631)						
128.49	0.9781***	—	—	-0.9781	—	0.9569	1.16
(0.9708)	(16.971)			(16.971)			
-14.4608	0.9515***	—	—	—	103.894**	0.9656	1.18
(0.1115)	(21.476)				(2.149)		
67.1433	0.9360***	—		-4.4742	104.057	0.9720	1.23
(0.5601)	(23.080		-7.2426***	(0.794)	(2.386)		
			(2.263)				
-6.4645	0.9554***	—	-7.8872**	-4.4742	111.117**	0.9714	1.25
(0.0474)	(20.005)		(2.365)	(0.795)	(2.470)		
			Log Linear Model				
-0.4322	0.9520***	—	-0.0204*	—	—	0.9646	1.21
(0.0208)	(22.933)		(1.801)				
0.5839	0.9203***	—	—	—	0.1029**	0.9677	1.17
(0.0297)	(21.365)				(2.289)		
0.7512	0.7094***	0.3423	—	—	0.0949**	0.9683	2.0
(0.0385)	(3.856)	(1.179)			(2.112)		
0.6546	0.9152***	—	-0.0179	—	0.0948**	0.9709	2.06
(0.06355)	(22.238)		(1.743)		(2.210)		

Figures in the parenthesis are the 't' values of the respective parameters.

*** *Indicates significant at 0.01 level with the sign shown.*

** *Indicates significant at 0.05 level with the sign shown.*

* *Indicates significant at 0.10 level with the sign shown.*

Table 2
Structural Coefficients of Acreage Response of Wheat in Ludhiana
(1965–66 Through 1983)

Constant	Regression Coefficients on A_{t-1}	NI_{t-1}	VP	VY	RP_{t-1}	$\bar{R}^2$	DW
			Linear Model				
68.384	0.8264***	—	—	—	8.7054***	0.9420	2.0
(3.3513)	(15.635)				(3.305)		
72.151	—	2.1527***	—	-1.0094**	—	0.8653	1.54
(2.4605)		(5.945)		(2.183)			
-17.9761	—	2.8534***	—	—	12.1108***	0.9073	1.77
(0.8815)		(12.169)			(3.581)		
			Log Linear Model				
1.1707	0.7764***	—	—	—	0.1021***	0.9430	1.19
(0.5603)	(15.473)				(3.324)		
1.0867	—	0.9731***	—	—	0.1551***	0.9176	2.2
(0.4293)		(12.714)			(4.172)		
0.7761	0.8423**	—	—	0.0203	0.1082***	0.9436	2.4
(0.3686)	(10.612)			1.068	(3.482)		

Figures in the Parenthesis are the 't' Values of the respective parameters.

*** *Indicates significant at 0.01 level with the sign shown.*

** *Indicates significant at 0.05 level with the sign shown.*

* *Indicates significant at 0.10 level with the sign shown.*

Table 3

Structural Coefficients of Acreage Response of Wheat in Amritsar Regression Coefficients on (1965-66 Through 1982-83)

Constant	A_{t-1}	NI_{t-1}	VP	VY	RP_{t-1}	R^2	DW
			LINEAR MODEL				
15.371	0.8979***	–	–	–	10.7097**	0.9636	2.6
(1.1760)	(19.498)						
-1095.914	–	14.016***	–	–	23.051***	0.9701	1.47
(18.010)		(21.584)			(6.359)		
-616.421	0.4007**	7.9366***	–	–	17.6090***	0.9791	2.4
(2.6731)	(2.556)	(3.252)			(4.750)		
-8.369	0.9700	–	–	-0.07868*	11.196***	0.9698	2.5
(0.5472)	(17.161)			(1.906)	(3·056)		
-637.327	0.4743***	7.9036***	–	-0.7802**	18.062***	0.9869	2.9
(3.4954)	(3.749)	(4.099)	–	(2.876)	(6.157)		
			LOG LINEAR MODEL				
0.8034	0.8534***	–	–	–	0.0789**	0.9578	2.4
(0.422)	(17.816)				(2.585)		
-1.9091	–	5.4074***	–	–	0.1619***	0.9261	0.90
(6.4073)		(13.558)			(4.179)		
-5.9520	6.5824***	1.8136*	–	–	0.1049***	0.9638	2.3
(1.1962)	(3.667)	(1.797)			(3·300)		
-8.0751	0.5720***	2.2844**	–	-0.0236	0.1158***	0.9681	2.2
(1.6536)	(3.837)	(2.285)		(1.626)	(3.793)		

Figures in the parenthesis are the 't' values of the respective parameters.

*** *Indicates significant at 0.01 level with the sign shown.*

** *Indicates significant at 0.05 level with the sign shown.*

* *Indicates significant at 0.10 level with the sign shown.*

ANNEX 1

Zero Order Correlation Matrix of Selected Factors Allocating Wheat Acreage: Region-wise.

	NI_{t-1}	VP	VY	RP_{t-1}	A_t
			PUNJAB		
t—1	+0.9729	—0.1795	—0.5891	0.3451	0.9804
NI_{t-1}		—0.2580	—0.6026	0.3801	0.9677
VP			0.2951	—0.0604	—0.2590
VY				—0.3484	—0.5845
RP_{t-1}					+0.5845
			LUDHIANA		
A_{t-1}	0.9670	0.1119	—0.7198	—0.1409	0.9526
NI_{t-1}		0.1093	—0.6488	—0.2237	0.9167
VP			0.1258	—0.0400	0.0121
VY				—0.2530	—0.7522
RP_{t-1}					0.0691
			AMRITSAR		
A_{t-1}	0.9626	0.0080	—0.6726	0.0906	0 9753
NI_{t-1}		0.0601	—0.6384	—0.0672	0.9454
VP			—0.0112	—0.2979	—0.0397
VY				—0.01122	—0.5996
RP_{t-1}					0.2193

For specification of A_t, A_{t-1}, NI_{t-1} RP_{t-1}, VP, VY, Please see Text.

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