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An Analysis of Allocative Efficiency of Wheat Growers in Northern Pakistan

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I. INTRODUCTION

For the last couple of years several agricultural and trade experts have been advocating if Pakistan has to compete in the international market for export of agricultural products then it needs to decrease the cost of production. In the light of Agreement on Agriculture of WTO, member countries are required to provide increased market access, decrease domestic support and tariff. These agreements are likely to increase the cost of production of various agricultural products for farmers producing these products, and make international competition tougher for export of agricultural commodities.

There are three possible ways to decrease the cost of production—by decreasing cost of inputs, by developing cost effective high yielding technologies or by improving management practices. There is little hope for decrease in the cost of inputs. Over the recent years prices of the petroleum products, were revised upward several times and this trend is likely to continue in future. Similarly, there was increase in the prices of gas, electricity and other agricultural inputs. Historically, in Pakistan, increase in prices of agricultural inputs has been much higher than the increase in prices of agricultural outputs [Pakistan (1988)]. Under these circumstances there is little hope of decease in prices of agricultural inputs. As far as development of new agricultural technologies, particularly high yielding varieties, is concerned it is a long-term process. It takes several years to develop a new variety and in its formal approval for distribution to farmers. Nevertheless, there is room for decreasing cost of producing through improvement in the management practices. When economists talk about improvement in the management practices they talk in terms of 'technical efficiency' and 'allocative efficiency'. Technical efficiency has been defined as firm's ability to produce maximum output given a set of inputs and technology. Allocative (or price) efficiency measures firm's success in choosing

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optimal proportions, i.e. where the ratio of marginal products for each pair of inputs is equal to the ratio of their market prices. Technical efficiency plus allocative efficiency constitute economic efficiency.

In Pakistan several studies have tried to measure technical efficiency of farms but little work has been done to estimate allocative efficiency. According to these studies farmers' technical efficiency, in Pakistan ranges from 57 to 88 percent [see Ali and Chaudhry (1990); Shah, *et al*. (1995); Shafiq and Rehman (2000); Bashir, *et al*. (1994); Ahmad and Qureshi (1999); Ahmad and Shami (1999) and Battese, *et al*. (1986)].

Generally, in Pakistan, input recommendations for various crops are blanket, irrespective of soil type, water availability, marketing costs and financial status of farmer. Research trials are undertaken on agricultural research stations and the recommendations are made for a wide area, based on these trials. Each year prices of several inputs are revised but there is seldom any change or revision in the recommended level of inputs. Under these circumstances there is need to explore whether farmers are allocating their resources optimally, or how efficient they are allocatively.

This study was directed in Peshawar valley to determine the wheat grower's allocative efficiency. Peshawar valley is known for its rich soil, hard working farmers and diversity of crops and orchards grown in the area. Majority of farmers is small and medium sized and most of agricultural farms are irrigated by the canal-irrigated system.

II. REVIEW OF LITERATURE

The general way to estimate allocative efficiency, in cross sectional data is to test the equality between the estimated Marginal Value Product (MVP) and Marginal Factor Cost (MFC). Lau and Yotopolous (1982) proposed profit function to estimate both technical and allocative efficiency. Yotopolous and Lau (1979) and Jamison and Lau (1982) found that Indian farmers were profit maximisers. In contrast, Junankar (1980) observed that Indian farmers were not maximising profit. Stefanou and Saxena (1988), using a generalisation of the Yotopolous and Lau approach, allowed training variables, education and management experience, to influence efficiency directly.

The approach suggested by Lau and Yotopolous (1982) uses an average profit function and cannot handle flexible functional forms. In contrast, the approach proposed by Kopp and Diewert (1982), and Zieschang (1983) permits flexible functional forms and utilises the information in the frontier cost function. Their approach draws on using the Farrell's notion of efficiency and the generalisation suggested by Kopp (1981). It decomposes the deviations from a frontier cost function into technical and allocative components. This approach and the approach suggested by Lau and Yotopolous bases upon duality theory and do not require the direct knowledge of frontier technology or its parameters. For the situations where duality does not hold (e.g. uncertainty and dynamic analysis, see Taylor (1986) for details) this approach may not be very useful. Moreover, in the approach of Lau and Yotopolous, it is not clear whether the error in the profit function comes from deviations from the production or from price inefficiency. Schmidt and Lovell (1979) suggested an alternative approach, using the behavioural assumption that the firm seeks to minimise cost. Using this approach Ali (1986), Kalirajan and Shand (1986) and Kumbhakar (1987) found that farmers are both technically and allocatively inefficient.

Schmidt and Lovell's method treats the error in the production, and price in a systematic way and requires data on farm specific prices. Also, in case of dual approach farm specific prices are needed. In developing countries prices of important commodities are fixed by governments, hence dual approach on cross sectional data may not work. However, in case of Peshawar Valley it may not happen because significant variations were found in the transportation cost as well as in the use of various agricultural inputs.

III. METHODOLOGY

This study was conducted in an irrigated area of Peshawar Valley. Three districts—Peshawar, Mardan and Charsadda—were the universe of the study. The data was collected through a pre-structured questionnaire from January to June 2005 through several visits. In each district five villages were selected through a multistage stratified sampling. Two hundred respondents were interviewed for the study. The sampling proportion from the sample villages was selected by the following formula:

$$n_k = nN_k \div \sum_{K=1}^{15} N_k$$

Where, n_k is the proportion of the sample in the k_{th} village, n is the size of the sample and N_k is the number of farm households of the k_{th} village. The total operated area of the respondent farmers was taken for the study.

Econometric Model

When specifying an econometric model the choice of functional form often poses a problem since the economic theory does not usually provide a precise guide. The choice of functional form can have important implications for subsequent statistical tests, forecasts, and policy analysis [Hall (1978); Mizon (1977) and Godfrey and Wickens (1981)]. It is also argued that specification of model should be guided by visualisation of the true process and this is determined by nature, not by econometricians. In order to identify a true functional form, which best fits the data of this study, the attention was drawn to translog production function. The translog production function is a member of de Janvry's generalised power production function family. In this functional form the percent change in the input ratio with respect to percent change in the marginal rate of substitution is not constant along the isoquant but varies from point to point. The translog production function can be generalised to include any number of input categories, and each pair of input may have a different elasticity of substitution. The general form of the function is

$$LnY = \beta_0 + \sum_{i=1}^{n} \beta_i \ lnx_i + \sum_{i=1}^{n} \sum_{j=1}^{n} \beta_{ij} \ lnx_i \ lnx_j$$

Where Y is the output, x_i are inputs and $\beta_0, \beta_i, \beta_{ij}$ are the parameters to be estimated. Sometimes, squared terms of x_i are also included [Christensen, Jorgenson, and Lau (1973)]. For translog the shape of isoquant heavily depends upon β_{ij}'s; if these are equal to zero, the translog model would reduce to the Cobb-Douglas model.

So, the most restricted form of translog production function is the Cobb-Douglas or log linear (*ln-ln*) form.

To compare the *ln-ln* model against the linear model Godfrey and Wicken's (1981) Lagrange Multiplier (LM test) was used. This approach is capable of selecting or rejecting both models, or selecting one rather than the other. The test statistic is

$$S^* = TR^2 \sim \chi^2_{(1)}$$

Calculation required to compute the test statistics are given in the appendix. S^* has a Chi-squared distribution [$\chi^2_{(1)}$] with one degree of freedom. T is the size of sample and R^2 in the uncertered R^2 obtained from regression explained in the appendix. The value of test statistic was close to zero for both linear and log linear forms. So, under this test neither linear nor *ln-ln* form could be rejected. After this another specification test, Sargan (1964) criteria, was applied to make a choice between linear and *ln-ln* forms. Under Sargan criteria the test statistic is

$$S = (\sigma_u / g\ \sigma_v)^T$$

Where σ_u and σ_v are standard deviations of error terms obtained when the ordinary least squares (OLS) is run on linear and *ln-ln* forms respectively. T is the sample size and g is the geometric mean of dependent variable. Sargan's criteria is if $S < 1$, then *ln-ln* model is preferred. The calculated value of S was 1.5684 implying *ln-ln* specification better suits to the data under study.

Both Cobb-Douglas and translog are *ln-ln* forms. We need to further test which one will suit to our data. Cobb-Douglas is the most restricted form of translog. When all interaction coefficients (β_{ij}'s) are zero translog reduces to Cobb-Douglas form. So, we need to test whether all β_{ij}'s are zero. For this purpose an F-test [Koutsoyiannis (1977)] was used. The hypotheses were

H_o = All 36 restrictions are true
H_1 = Not all restrictions are true

The statistic was computed as under:

$$F^* = \frac{\left[\sum e_r^2 - \sum e_u^2\right]/C}{\sum e_u^2/(T-K)}$$

Where Σe^2_r and Σe^2_u are sum of residuals squared from restricted and unrestricted model estimated by OLS method, C is the number of restrictions and T-K is the degree of freedom for unrestricted model. F^* has F distribution. The calculated F was 2.36 with C = V1 =36 and T-k = 155; p-value being 0.0014. Therefore H_o was rejected. The restricted translog model is as under:

$ln\ OUTPUT = ln\ \beta_o + \beta_1\ ln\ RWFL + \beta_2\ ln\ NPL + \beta_3\ ln\ DPL + \beta_4\ ln\ RSM + \beta_5\ ln\ N + \beta_6\ ln\ P_2O_5 + \beta_7\ ln\ I + \beta_8\ ln\ MG + \beta_{11}\ (ln\ RWFL)^2 + \beta_{22}\ ln\ (NPL)^2 + \beta_{33}\ (ln\ DPL)^2 + \beta_{44}\ (ln\ RSM)^2 + \beta_{55}\ (ln\ N)^2 + \beta_{66}\ (ln\ P_2O_5)^2 + \beta_{77}\ (ln\ I)^2 + \beta_{88}\ (ln\ MG)^2 + \beta_{15}\ ln\ RWFL^*\ ln\ N + \beta_{16}\ ln\ RWFL^*\ ln\ P_2O_5 + \beta_{17}\ ln\ RWFL^*\ ln\ I + \beta_{23}\ ln\ NPL^*\ ln\ DPL + \beta_{24}\ ln\ NPL^*\ ln\ RSM + \beta_{34}\ ln\ DPL^*\ ln\ RSM + \beta_{56}\ ln\ N^*\ ln\ P_2O_5 + \beta_{57}\ ln\ N^*\ ln\ I + \beta_{67}\ ln\ P_2O_5 {}^*ln\ I$

Description of variables is given in the section "Results and Discussion"

Byerlee (1987) proposed that for policy purpose, it would be a useful exercise to further divide the allocative inefficiency into two categories (a) constrained case where allocative gains are measured by reallocating '*i*' inputs within a constant cost level, and (b) the unconstrained case where allocative gains accrue due to movement along the expansion path until the marginal cost on expenditure is equal to marginal revenue.

For the present study, keeping in view more policy relevance, constrained allocative errors of farmers were considered. It is assumed that an individual farmer has fixed land, labour and cash outlay and his objective is to maximise his output by extending the given cash outlay.

Let estimated production frontier is:

$$Y = f(x, b)$$

Where x is vector of inputs, b is estimated vector of coefficients and Y is output of individual farmer.

Let farmer's outlay C_o is

$$C_o = \sum_{j=1}^{m} V_j X_j$$

Where v_j in the price of jth input X_j and 'm' denotes the number of variables purchased.

Farmer's output maximising problem can be expressed as:

Maximise $f(x, b)$

Subject to

$$C_o = \sum V_j X_j$$

The first order condition for constrained output maximisation problem will be:

$$f_1 / f_i = v_1 / v_i$$

Where f_1 and f_i denote the first order derivatives of Y with respect to x_1 and x_i respectively. Where as v_1 and v_i are their prices. Cost constrained output (Y) of the farmer can be obtained by substituting the cost constrained maximising input levels (x_1*…..x_m*) in the production frontier. Allocative efficiency of each individual farmer was determined by calculating the ratio of predicted output (Y) from estimated production function to cost constrained maximum output (y).

IV. RESULTS AND DISCUSSION

There were high variations in the yield among sample farmers depending upon the use of inputs and farmers management practices. Average wheat yield of farmers surveyed was 905 kg per acre; minimum being 305 kg and maximum being 1575 kg per acre. Summary statistics of variables is given in Table 1.

Table 1

Summary Statistics of Variables Used in the Analysis

(Number of Observations = 200)

S. No.	Variable*	Unit	Mean	Standard Deviation
1.	NPL	No.	3.757	0.788
2.	DPL	No.	0.535	0.542
3.	RWFL	Ratio	0.715	0.462
4.	RSM	Ratio	0.741	0.421
5.	N	Kg	26.202	9.312
6.	P_2O_5	Kg	10.451	7.213
7.	I	No.	4.112	1.213
8.	MG	Years	22.27	6.51
9.	Y	Kg	905	2.344

*Variables are defined in the following section.

Variables Used in the Analysis

Variables used in the analysis are defined as under:

Wheat Yield (Y): Wheat yield per acre in Kgs. It is dependent variable

Normal Plowings (NPL): Total number of plowings using tine cultivator and/or with animals using local plow per acre.

Disc Plowings (DPL): Total number of plowings by disc plow per acre.

Ratio of Wheat Acreage Following Fallow Land (RWFL): Wheat acreage of a farmer following fallow lands divided by the total wheat acreage of that farmer.

Ratio of Wheat Acreage Sown by the Recommended Sowing Method (RSM): Wheat acreage planted by recommended sowing method by a farmer divided by total wheat acreage of wheat farmer.

Nitrogen (N): Kg of Nitrogen (nutrients) applied per acre.

Phosphorous (P_2O_5): Kg of P_2O_5 applied per acre.

Management (MG): Total number of schooling years plus age of a farmer divided by 2.

About one third of the wheat crop area was sown during the optimum range of sowing time. Only seven percent of the sample farmers were found using certified seed and twenty seven percent practiced weed control. Sowing time, weed control and use of certified seed are important variables, which can significantly affect the wheat productivity [Byerlee (1987); Hobbs (1985)]. A limitation of the study relates to the use of irrigation water. To capture the effect of irrigation water on wheat yield we have used the variable "number of irrigations". Quantity of water for each irrigation can vary from farm to farm or even from field to field. However, there were also some timely rains during the wheat-growing period.

Restricted translog production function was used to estimate the production coefficients. Results are given in Table 2.

Allocative efficiency of individual farmer was estimated by calculating the ratio of predicted output (Y) from estimated production function to cost constrained maximum output. Detailed procedure is explained in the methodology section. The average allocative efficiency of sample farmers was 72 percent ranging from 51 to 88 percent. Majority of sample farmers was centred around the mean allocative efficiency.

To see whether cash constrained solution satisfies the marginal conditions for maximisation, the following relationship was compared.

$$P\partial f/\partial x_i = v_i$$

Where P is the price of output, $P\partial f/\partial x_i$ is the marginal product of input i and v_i is the price of input i. Forsund, *et al.* (1980) defined this condition for scale efficiency.

To analyse the allocative efficiency of each input, percentage deviations of actual input levels from cost constrained optimum levels were computed. Sixty two

Table 2

Estimates of the Constrained Translog Production Function

(Number of Observations = 200)

Independent Variable	OLS Coefficients	*T*-value
Constant	0.43185*	(3.573)
In NPL	0.3825***	(1.403)
In DPL	0.0826	(1.288)
In RWFL	0.0798***	(1.427)
In RSM	–0.06746	(–1.132)
In N	0.05257*	(6.873)
In P_2 O_5	0.08657*	(5.343)
In I	0.49165*	(3.965)
In MG	0.07843	(0.687)
(In NPL)2	0.1065	(0.432)
(In DPL)2	0.21675	(1.194)
(InRWFL)2	0.01273***	(1.295)
In RSM)2	–0.035484**	(–1.753)
(In N)2	0.032793*	(2.897)
(In P_2 O_5)2	0.098743*	(2.815)
(In I)2	–0.25173*	(–3.817)
(InMG)2	0.032701	(0.4808)
In RWFL * In N	0.001517	(0.3275)
In RWFL * In (P_2O_5)	0.016782	(0.2717)
In RWFL * In I	0.013452	(0.2617)
In NPL * In DPL	0.02476***	(1.418)
In NPL * In RSM	–0.03541***	(–1.437)
In SPL * In RSM	0.00000	(0.0000)
In N * In (P_2O_5)	0.00398**	(1.954)
In N * In I	0.00289**	(1.815)
In P_2O_5 * In I	0.0000	(0.0000)
Adjusted R2	0.8735	

NPL = number of normal plowings.
DPL = number of disc plowings.
RWFL = wheat acreage following fallow land divided by total wheat acreage.
RSM = wheat acreage sown by recommended sowing method divided by total wheat Acreage.
N = nitrogen (kg/acre).
P_2 O_5 = phosphorous (kg/acre).
I = number of irrigations.
Mg = management: total year of schooling plus age of the farmer divided by 2.
*, **, *** Significant at 1 percent, 5 percent and 10 percent level respectively.

percent of farmers were using less nitrogen than optimum level required to obtain maximum output given the cost outlay. Similarly, eighty three percent of farmers were using less phosphorous than the optimum level. However, the use of tillage was found higher than the optimum level. Fifty six percent of farmers were efficient in use of tillage and 67 percent in use of irrigation water.

Factors Affecting Allocative Efficiency

Theoretically, factors affecting the allocative efficiency are experience of the farmer, his level of education, level of awareness about improved technology and availability of cash. During discussion with farmers, at the time of data collection, these theoretical considerations were further supported. Level of awareness included the sum total extension contacts, discussions with other farmers about input use, number of times the farmer listened to agricultural programs on the radio in a week during the wheat growing period, number of times the farmer watched agricultural programs on TV, and reading of agricultural magazine. An index was constructed for level of awareness. Farm size was used as proxy for cash availability, i.e. cash available to a farmer. Dependent variable is the allocative efficiency of the wheat growers. A linear relationship was assumed between dependent and independent variables. Results of OLS regression are summarised in Table 3.

Table 3

Regression Results of Factors Affecting Allocative Efficiency

Independent Variable	OLS Coefficients
Constant	0.234
	(6.653)
Education	0.287*
	(3.512)
Age	0.140
	(0.467)
Awareness	01.38*
	(4.516)
Farm Size	0.059***
	(1.678)
Adjust R2	0.683

[1]Figures in parenthesis are *t*-values.
*, ***Significant at 1 percent and 10 percent levels respectively.

The coefficients of education and awareness are positive and significant at 1 percent level of significance. It means that allocative efficiency of farmers is directly related with the levels of education and information. The coefficient of farm size was positive and significant at 10 percent level of significance. Most of the allocative inefficiencies were observed in use of fertilisers. Fertilisers were not available at the village level. These had to be purchased from the local markets, which were located at a distance of 3 to 10 miles from the research sites; other inputs were available at the village level. Use of herbicides was not popular among farmers.

V. CONCLUSION

Level of fertiliser use in Peshawar valley is much below the optimum level. The use of tillage and irrigation were marginally higher than the profit maximising level. To encourage the use of fertiliser there is need to improve the input supply system, to provide credit facilities and to motivate farmers through appropriate extension methods.

Appendices

I. Godfrey and Wicken's Specification Test

Godfrey and Wickens (1981) developed this test for testing the adequacy of linear and log linear functional forms specification. Following are the possible outcomes under this test.

(1) Select both the forms
(2) Reject both the forms
(3) Select one form and reject the other

Procedure is illustrated as under:

1. Assume the linear regression equation is

$$M_1 : y_t = \sum_{j=1}^{k} \beta_{ti} X_{ti} + u_t \quad t = 1,...,T$$

and log linear relationship is

$$M_2 : lny_t = \sum_{j=1}^{k} \beta_{ti} \ ln \ X_{ti} + v_t \quad t = 1,...,T$$

Where, y_t are observation on outputs and x_{ti}'s are physical inputs (I = 1,…,k) and ß$_{ti}$ (i =1,…,k) is the vector of coefficients including intercept term and u_t and v_t are random errors in expressions M_1 and M_2 respectively.

2. Run the regression M_1
3. Compute variables Q_t, A_t B_t, C_t and D_t as follows

$$Q_t \left[y_t \ ln \ y_t - y_t + 1 \right] - \sum_{j=1}^{k} \beta_i \left[X_{ti} \ ln \ X_{ti} - X_t \right]$$

$A_t = \ln y - [Q_t\, u_t / б^2_u]$

$B_t = [2\, б_u]^{-1} [u^2_t - б^2_u]$

$C_{ti} = [X_{ti} - 1]\, u_t / б^2] \quad i = 1,\ldots,k$

$D_t = u / б^2$

4. Regress a vector of 1's on A_t , B_t , C_{ti} and D_t
5. Compute the test statistic $S^* = TR^2$
6. S^*_{is} distributed Chi-square $[X\ (1)^2$ with one degree of freedom. If S^* is significant reject M_1, otherwise not.

The above six steps can be followed for specification of M_1.

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Comments

I must congratulate Dr Muhammad Bashir and Mr Dilawar Khan for undertaking research on a very important topic. The authors have used farm level data to estimate growers' allocative efficiency in Northern Pakistan. They have benefited from a sizeable and very rich literature on the topic. However, I have few suggestions that would help improving the quality and usefulness of the study if incorporated.

In the study area, like other areas of Pakistan, farming is a multi-output multi-input enterprise. Therefore, we can talk about the overall allocative efficiency as well as efficiency in case of individual enterprises (crops, livestock or others) and with respect to certain input(s). The author should make it clear in the beginning of the paper and should not leave it for the reader to infer from the results presented. It is the discussion on page 9 which hints that the allocative efficiency of wheat growers is being estimated. It would be better to incorporate the enterprise in the title modifying it as "An Analysis of Wheat Growers' Allocative Efficiency in Peshawar Valley".

In the methodology section, it is mentioned that the village level sample was selected proportionately to respective population. It would have been better if sample proportions were based on number of farm households in each village rather than population.

The authors justify the use of a translog production function for the study that most of the agricultural economists have used it. This is not a good reasoning; the function must have desirable properties that provide justification for its wide use by the researchers. The statement of these properties would be a better argument.

The period during which farm survey was conducted is mentioned as January to June 2005. It looks that either the survey is multi visit survey or the data does not belong to wheat crop 2004-2005. The authors need to make it clear.

The second para on page 8, as it appears gives the impression that the model has been tested using Lagrange Multiplier and Sargen "S" statistics and found ln-ln specification better fits the data. It is not possible that the authors tested the model before even specifying it. The para needs to be revised. Moreover, the Cobb Douglas functional form is also a ln-ln form why did not it fit better for the study under discussion.

The authors have used the restricted translog model without mentioning restricted in what sense. Later at page 11 it is stated that a constrained translog production function was used to estimate the production function. The authors should be explicit whether the restricted and constrained production function terminology is being used alternatively or are they using the terms in some different sense.

The estimated translog production function includes a variable on management (MG) among other independent variable and is defined as the average of schooling years and farmers' age. In this way the same weight is attached to age and schooling years. Why not include them separately, as the data is available on both the variables.

Soon after the table giving estimated coefficients for constrained translog production function (which were never explained), the authors stated the average allocative efficiency of sample farmers was 72 percent without even mentioning that such efficiencies were computed using such and such procedure or formula.

The first sentence in the last paragraph on page 13 mentions that the authors realised during the discussion with farmers, at the time of data collection, that important factors affecting allocative efficiency are age (experience), education, awareness about technology, and availability of cash. The authors must have benefited from research addressing determinants of allocative efficiency and therefore, included questions regarding these important variables in the questionnaire, therefore these studies should be also referred and given credit instead of giving whole credit to the discussion with farmers (who might not even know what allocative efficiency is).

The dependent variable in regression estimated to identify the factors affecting allocative efficiency is never made explicit. There will be an allocative efficiency estimate w.r.t to each input included in the model and for each of them different factors may be important.

The discussion of results and the concluding section are too brief to make much sense. In addition, there are certain typo mistakes throughout the paper and need to be removed. Some of the references listed are not cited anywhere in the paper and dates for some of the cited studies differ from those given in the references.

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