Education and Technical Efficiency
in Pakistan's Agriculture

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I. INTRODUCTION

It is now well recognized that education expedites the process of growth in an economy. In agriculture, leaving aside the external effects, it affects productivity in two quite distinct ways known as the allocative effect and the worker effect (Welch, 1970). The former centres on better allocation decisions including adoption and diffusion of new technology whereas the latter relates to a more efficient use of given inputs, i.e., the technical efficiency aspect of production. While the allocative effect is inherently predicated on disequilibrium (created, for example, by a change in technology) (Nelson and Phelps 1966), there is some evidence to suggest that *even the worker effect of education is more likely to arise in disequilibrium resulting from technical change* (Moock 1981). This is because technical change renders the cultural practices learnt over generations obsolete or inadequate and calls for an adjustment. A more educated farmer is supposed to make the required adjustment more quickly. In this paper I have attempted to test this hypothesis for Pakistan during the green revolution period when the introduction of new crop varieties disturbed the prevailing equilibrium. For this purpose I have used production function analysis and have conducted the analysis for not only the new but also the traditional crops. The results lend support to the hypothesis by showing that the worker effect is more pronounced in the case of new crop varieties as compared to the traditional ones. The paper is divided into three sections. In Section II, I have presented the hypothesis and discussed the methodology used for the analysis. Section III concludes the paper with a discussion of the results.

II. THE HYPOTHESIS AND METHODOLOGY OF ANALYSIS

In this paper I have focused only on the effect of education on technical efficiency which resides, as pointed out earlier, in the better utilization of *given*

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inputs. For example, introduction of new crop varieties may require not only modern inputs (like pesticides, insecticides and chemical fertilizers etc.) but also an application of these inputs at an appropriate time. It is quite possible that two farmers applying exactly similar physical inputs get different outputs due to differences in the timing of input application. This difference then will be attributed to the technical efficiency.

I have carried out the analysis for both the new and the traditional crop varieties. Four major crop varieties of Pakistan were included in the analysis, two of which namely wheat (Mexipak) and rice (IRRI),[1] are the high-yielding varieties (HYVs) introduced in the wake of the Green Revolution in the late Sixties, while the remaining two, i.e., cotton and sugar-cane, have traditional origins.[2]

For each of these crops I have estimated the engineering production function (Welch 1970) using cross-sectional data, for the entire irrigated region of Pakistan spanning the whole of the Indus basin, for the year 1976-77. These data are taken from the water-course survey conducted jointly by Pakistan WAPDA (Water and Power Development Authority) and the World Bank. Apart from the benefit of having a consistent and reasonably large data set, the year 1976-77 seems quite appropriate for the study under consideration for the following reason. Although both the HYVs included in this study were introduced in the late Sixties (1968 and 1969 respectively to be precise) their widespread adoption occurred only in the early 70s, and continued throughout the decade. According to Mohammad (1986, p. 501) by 1972 only 52 percent and 42 percent of the cropped area were under HYVs of wheat and rice respectively. By 1980, the corresponding figures stood at 69 percent and 50 percent.[3] Therefore, the 1970s can be characterised

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[1]Mexipak and IRRI refer to CYMMIT, Mexico and International Rice Research Institute, Manila respectively where these varieties were developed.

[2]In a similar sort of study Butt (1984) has attempted to capture the effect of education on farm productivity. He estimated the production function using gross value of production as the dependent variable for the same four crops included in this study. He wrongly attributes the resultant effect of education (more than four years of schooling turns out to be significant in one out of two of his equations) to only the worker effect. In the specification he uses the resultant effect is a combination of the allocative and worker effects as was pointed out by Welch (1970) [In fact Welch criticised Chaudhri (1968) on exactly the same grounds (p. 46)]. More seriously, however, by lumping all the four crops together in one regression equation, Butt assumes the effect of education to be identical for both the new and traditional crops which is contrary to the spirit of Nelson-Phelps hypothesis. The evidence presented in this study does not support such a presumption.

[3]Actually in the case of IRRI rice there was a reversal of trend especially for the large farms in favour of a traditional variety, Basmati. This was primarily due to its very high international price leading to a much higher procurement price as compared to IRRI. See Azhar and Mahmud (1984).

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as a period of disequilibrium in Pakistani agriculture — a period when, according to the Nelson-Phelps hypothesis the impact of education is likely to be strong.

It is common in studies dealing with agriculture to use a Cobb-Douglas (CD) production function of the form;

$$Y_i = \gamma \prod_j^n X_{ij}^{\alpha_j} \qquad j = 1, \ldots, n \qquad \ldots \quad (1)$$

Where Y_i and X_{ij} are output and quantities of inputs respectively for the ith farm. In the present case, estimation of the resultant log-linear equation posed a problem not uncommon in such microeconomic data sets. For a number of farms certain inputs attained zero value. This was specifically the case with education (years of schooling). Dropping these observations from the analysis meant a significant reduction in the number of observations. At any rate the remaining sample would then become somewhat biased. The customary adjustment of substituting a very small number in place of zeros was considered undesirable particularly because for education the mean value for the entire sample was very low, and the substitution of even a small number, like .01, could bias the results.

Therefore I have used a slightly modified version of the CD production function in which the inputs that could, in principle, attain the zero value (in a way nonessential inputs) are introduced as shift variables. The production function used is specified as;

$$Y_i = A_i \prod_j^n X_{ij}^{\alpha_j} \qquad j = 1, \ldots, n \qquad \ldots \quad (2)$$

where

$$A_i = \gamma e^{\sum_k^m \beta_k Z_{ik}} \qquad k = 1, \ldots, m \qquad \ldots \quad (3)$$

and hence

$$Y_i = \gamma \prod_j^n X_{ij}^{\alpha_j} e^{\sum_k^m \beta_k Z_{ik}} \qquad \begin{array}{l} j = 1, \ldots, n \\ k = 1, \ldots, m \end{array} \qquad \ldots \quad (4)$$

In this formulation the Z_{ik}'s represent the shift variables, while X_{ij}'s are the inputs that could be regarded as essential inputs.

In the following analysis, the essential inputs include only two inputs, i.e., land (N) and labour (L). L implicitly includes those essential capital inputs which are more or less complementary to labour like farm implements etc. Fertilizer,

both nitrogenous and phosphorous, farmyard manure, irrigation, and schooling of
the farmer are included as shift variables. For the four crops under consideration,
the following regression equation is estimated using Ordinary Least Squares (OLS)
methodology;

$$\ln Y = C_0 + \alpha_0 \ln N + \alpha_1 \ln l + \beta_1 r + \beta_2 n + \beta_3 p + \beta_4 m + \beta_5 s \quad \ldots \quad (5)$$

where

Y = farm crop output (maunds[4]);
N = farm crop area (acres);
l = labour input (man days/acre);
r = irrigations (numbers/acre);
n = nitrogenous fertilizer (kgs./acre);
p = phosphorous fertilizer (kgs./acre);
m = farmyard manure (kgs./acre); and
s = years of schooling of the farmer.

In Equation (5) all variables except output and schooling are expressed in per
acre terms. Output is expressed as total farm output. This in conjunction with the
inclusion of N, crop area, as an explanatory variable is expected to shed some light
on the degree of homogeneity of the production function in terms of essential
inputs, that is land and labour, subject to the existing state of technology represented
by the existing values of shift variables.

Normally, in production function studies, irrigation is not included as an
explanatory variable due to the lack of sufficient variation in the amount of irriga-
tion used across farms. That presumption would be acceptable for Pakistan if the
only source of irrigation were the public irrigation network. That, however, is not
the case. Public irrigation, in the recent past, has been considerably supplemented
by private tubewells. As a result the data reveal a significant farm to farm variation
in the type of irrigation. This led to the inclusion of the type of irrigation as an
explanatory variable in the present study to capture the effect of private tubewells
on farm productivity.

III. RESULTS

The results of the estimated equation are reported in Table 1. These results
are quite encouraging both on account of significance of the coefficients and the
adjusted coefficients of determination, $\bar{R}^2_s$. The coefficients of N relate to the

[4]One maund is equal to 37.33 kgs.

Table 1

Results of the Estimated Equation for Four Leading Crops of Pakistan

| Crop | \multicolumn{8}{c}{Independent Variables} | $\bar{R}^2$ | Number of Observations |
	N	l	r	n	p	m	s		
Wheat (Mexipak)	1.025* (50.52)	0.008 (0.471)	0.08* (11.77)	0.008 (6.91)	0.004* (2.59)	0.002* (4.23)	0.018* (4.06)	0.7142	1370
Rice (IRRI)	0.926* (36.32)	0.097* (3.50)	0.019* (3.21)	0.006* (4.77)	0.0009 (0.34)	−0.0002 (0.33)	0.0153* (2.69)	0.7222	665
Cotton	1.001* (28.20)	0.029 (0.754)	0.097* (5.185)	0.0008* (5.21)	0.0057* (2.042)	0.0003 (0.41)	0.014 (1.61)	0.6068	727
Sugar-cane	1.034* (35.17)	0.076* (2.54)	0.026* (4.651)	0.003* (2.30)	0.001* (2.07)	0.001 (0.62)	−0.004 (0.537)	0.6883	720

t = statistics in the parenthesis.
*significant at 5 percent.

degree of homogeneity of the production function in the essential inputs. For example, the coefficient of N being equal to one would imply linear homogeneity with the constraint that the state of technology does not change when N is changed. In other words, as long as the patterns of shift variables yield the same average inputs (which practically amounts to increasing all these inputs by the same proportion as N), an estimated coefficient of N equal to one implies constant returns to scale. The results in Table 1 show that the coefficient of N is not significantly different than one for three out of four crops, i.e., wheat, cotton, and sugar-cane. The fourth crop, rice, seems to display decreasing returns to scale. The coefficient of N is significantly different form one (in this case less than one). Still, the coefficient is very close to unity.

The coefficient of labour is significant in only two out of four equations. Given 1976-77 levels of labour utilization, variations in labour use across farms do not appear to account for a significant variation in wheat and cotton output.

Interestingly, both the crops for which the labour coefficient is significant, rice and sugar-cane, have relatively labour-intensive sowing operations. The coefficients for irrigation is significant in all the four equations. This indicates that private tubewells as a supplement to the public irrigation system affect agricultural productivity significantly.[5] Similar is the case with nitrogenous fertilizer. Its coefficient is significant in all four equations. Phosphorous fertilizer and farmyard manure coefficients are each significant in two out of four estimated equations.

The results with respect to schooling strongly support the hypothesis that it becomes important only in the face of new crop varieties. It is only when the introduction of new crop varieties renders the historical knowledge, embedded in the cultural practices learnt over generations, redundant or obsolete that education emerges as an instrument of change. The coefficients of the schooling variable are significant only in the case of the green revolution varieties of crops, namely Mexipak wheat and IRRI rice. For the two remaining crops, sugar-cane and cotton that have traditional origins, these coefficients are not significantly different from zero at the 95 percent confidence level. The results show that one additional year of schooling leads to 1.53 and 1.8 percent increase in farm output for rice and wheat respectively. These results compare *favourably* with those obtained by Pudasaini (1976) for Nepal (1.3 percent) and Wu (1971) for Taiwan (.7 percent). In both of

[5] We note that the marginal irrigation, *ceteris paribus*, leads to an almost 8 percent increase in output of wheat and cotton. For rice and sugar-cane, which are recognized as irrigation intensive crops, the increase is much smaller, around 2 percent and 2.6 percent respectively. Average number of irrigations for these is almost twice as large as for the other two crops. However it must be noted that sugar-cane is a full year crop. Therefore the average number of irrigations for the comparable period (six months) will be roughly the same as wheat and cotton.

Table 2

Results of the Estimation for Four Leading Crops of Pakistan with Schooling Dummies

Crop	Independent Variables								$\bar{R}^2$	Number of Observations
	N	l	r	n	p	m	d_1	d_2		
Wheat (Maxipak)	1.031* (50.93)	.0044 (.268)	.081* (11.811)	.008* (6.93)	.004* (2.542)	.002* (4.343)	−.037 (.427)	.096* (2.794)	.7123	1370
Rice (IRRI)	0.9244* (36.23)	.0916* (3.313)	.0185* (3.12)	.0064* (4.78)	.001 (.39)	−.0002 (.36)	.1736 (1.224)	0.169* (2.74)	.7222	665
Cotton	1.0026* (28.25)	.029 (.763)	.0791* (5.157)	.0082* (5.232)	.0055* (1.976)	.0002 (.35)	.1711 (1.074)	.0992 (1.466)	.6065	727
Sugar-cane	1.033* (35.31)	.079* (2.64)	.026* (4.63)	.003* (2.231)	.001* (.638)	.001* (2.044)	.087 (.597)	−.003 (.063)	.6879	720

= statistics in the parentheses.
*significant at 5 percent.

these studies education enters as the years of schooling completed by farm operators, which is similar to our specification.

It is now well established that mere elementary (primary, as it is known in Pakistan) education (4-5 years of schooling) does not affect productivity. Ever since Chaudhri (1968, 1979) rearticulated this idea of "lapses back into illiteracy"[6] it has been subjected to empirical test in the majority of studies in agricultural economics that focus on education's contribution to productivity. The results reported in Table 2 add yet another piece of evidence to this effect. The schooling variable, s, in this case is replaced with two dummy variables, d_1 and d_2 to represent one to four, and more than four years of schooling respectively. The results are exactly similar to the previous ones with respect to size and significance of co-efficients with a marginal improvement in the adjusted coefficients of determination, $\bar{R}^2$,s. The coefficients of d_1 are not statistically significant in any of the equations while those pertaining to d_2 are significant for the same two (HYVs of) crops. These results show that completion of education beyond elementary level (4 years) leads to a 9.6 percent increase in the farm productivity for wheat while in the case of rice the increase is almost 17 percent. These productivity gains come on the higher side of the corresponding gains in other countries which give an average figure of 7.4 percent as estimated by Lockheed *et al.* (1980, p. 61). Resulting, as they are, from just the technical efficiency, these gains are quite significant.

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[6]Chaudhri took the cue from Baily (1959) who concluded that the response of an elementary educated person to change may not be any different than that of an illiterate person.

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Comments on
"Education and Technical Efficiency
in Pakistan's Agriculture"

The author deserves compliments for venturing into an area untrodden by agricultural economists in Pakistan. He has analysed the information collected from the water course survey data conducted jointly by the Water and Power Development Authority, (WAPDA) and the World Bank. While appreciating his analyses and derived conclusions, certain observations have been made, which may help in further refinement of the paper.

In the first instance everybody is not familiar with this data. It would have been more useful if the author could describe the data set, the methodology used, and also cautioned the readers about limitations of such data, if any.

According to him he has "focused only on the effect of education on technical efficiency which resides . . . . . in a better utilization of given inputs. For example, introduction of new crop varieties may require not only modern inputs (like pesticides, and chemical fertilizers etc.) but also application of these inputs at an appropriate time." Application of modern inputs at the appropriate time presupposes the knowledge about the appropriateness of timing of the use of such inputs. It would be desirable to know what institutional arrangements were provided during the Green Revolution for making the farmers acquainted with the modern agricultural inputs.

While estimating the production function, the author has mentioned the use of shift as well as dummy variables. Normally they are considered as one and the same thing. It seems that the author has different meanings for them. If it is so, it would be desirable to enlighten the readers about the meanings attributed to shift and dummy variables.

The author has indicated m = farmyard manure (Kgs/acre). The readers conversant with farming may question the validity of such quantitative analyses. Farm manure is seldom weighed by the farmers in Pakistan. One wonders how this element could be subjected to any quantitative analyses. Similar is the case of another shift variable, i.e. irrigation (numbers/acre) which makes quantitative analyses rather difficult because here one has to take into consideration intensity of irrigation, timings of irrigation, institutional arrangement causing stoppage of irrigation etc.

The author has stated: "The schooling variables, d_1 and d_2 to represent up to four, and more than four years of schooling respectively". In the footnote, the author has stated "Some researchers have used five years . . . . . I have opted for four

years to maintain a consistency with the majority of the studies". It may be important to mention here that the structure of primary education in Pakistan comprises of 5 years and not four. Whatever analyses the author has undertaken on the basis of four years are therefore, rendered ineffective and the conclusions so drawn become distorted. In such a situation it is difficult to conclude that "mere elementary education (up to 4 years of schooling) is not sufficient to ensure a positive impact of education on productivity". Moreover, if elementary education is treated as four years, then a variable of having no schooling is also required to be included so as to allow comparisons of the contribution education can make in terms of productivity.

While examining the contribution of education in terms of enhancing technical efficiency of the farmers, it would be desirable to probe into the curriculum content at the primary and post-primary levels. It may have to be ascertained if the curriculum content incorporates the agricultural component which contributed to their technical efficiency in agriculture. If there is no such component, perhaps there were other factors like higher pay-off which triggered off higher yields.

The author has concluded that mere elementary education (upto 4 years of schooling) has not been sufficient to ensure a positive impact of education on productivity. While making this statement the author has probably overlooked the fact that the time gap between the completion of primary education and the start of farming operations had become so large that it almost amounted to a negation of the acquisitive factor. We may, however, endorse the conclusive statement of the author with a reservation that primary education is the edifice on which the structure of the subsequent stages of education is erected. Without primary education we cannot think of universal literacy and the promotion of Science and Technology for the development of the Pakistani nation.

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