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Relative Efficiency by Farm Size and the Green Revolution in Pakistan

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Using the "unit output price" profit function, the study analyses the relative efficiency of (a) old versus new seeds, and (b) large versus small farms in the production of new varieties of wheat and rice in the Indus Basin of Pakistan. It is found that whereas farm size has no effect on efficiency, high-yielding seeds are more efficient than seeds of old varieties. The study also finds that labour demand elasticities with respect to both land and capital are rather low.

In the literature on the "Green Revolution", questions about the relative efficiency of old versus new seeds of wheat and rice and of large versus small farms remain as controversial as the empirical evidence on them is scarce. Lau and Yotopoulos [5; 6], and Yotopoulos and Lau [9], using what is called the "Unit Output Price" (UOP) profit function, developed a theoretical model to test the relative efficiency of large versus small farms. Their studies were conducted on aggregated data for all crops from some regions of India. However, the same model has been applied by Sidhu [8] to test the relative efficiency of old versus new seeds of wheat, tractor farms versus non-tractor farms, and large versus small farms. He has used micro data from the Indian Punjab.

In our study, the UOP profit function approach is used to analyse the relative efficiency of (a) old versus new seeds of wheat and rice, and (b) large versus small farms in the production of the new varieties of wheat and rice. The tests are performed on the data collected from a sample of farms in the Indus Basin of Pakistan. We feel that this paper makes several contributions. Firstly, the Lau-Yotopoulos results generally suggested that large farms were less efficient than small farms, while Sidhu found no significant difference in efficiency by farm size in the production of wheat. Therefore, another test using a new set of data is useful since the question of relative efficiency of farm size is central to the formulation of public policy regarding land reform. Secondly, since the previous studies have dealt with India, it would be instructive to see if similar kind of relationships are found in a

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country which has been regarded as a major beneficiary of the "Green Revolution" and where the government in the Sixties opted for a "bimodal" strategy for agricultural development. Finally, since the adoption and use of the new seeds are not limited to wheat, our results comparing the old versus new seeds of rice provide a more complete assessment of the impact of the "Green Revolution". One limitation of our study regarding effects of farm size is that it deals with only two crops, which, though in themselves very important for Pakistan's economy, do not represent the total crop production function on a farm.[1]

Section I presents the model and data. The results of tests on the efficiency hypotheses for old versus new seeds and for large versus small farms and the indirect estimates of factor elasticities are described and the findings are compared with previous studies in Section II. Some policy conclusions are drawn in Section III.

I. THE MODEL AND DATA

Since the theoretical model developed by Lau and Yotopoulos [5] has already been elaborated in the relevant literature, we will not reiterate it here. Following their formulation of the profit function, we consider labour as the only variable input, since in our data it is also the only major factor for which the price varies among farms.

The estimating equations used for testing relative efficiency by farm size are

$$\ln P = b_0 + b_1 D_1 + b_2 D_2 + b_3 D_3 + b_4 D_4 + b_5 D_L + b_6 \ln W + b_7 \ln N + b_8 \ln K + e_1 \quad (1)$$

$$-\frac{WM}{P} = b_9 D_L + b_{10} D_S + e_2 \quad (2)$$

where the variables are:

P = profit in rupees, and is defined as: (price of output x physical quantity of output) – (wage rate per manday x number of mandays used);

D_1 = dummy variable, taking the value of unity for farms in Gujranwala district and of zero otherwise;

D_2 = dummy variable, taking the value of unity for farms in Sahiwal and Faisalabad (formerly Lyallpur) districts and of zero otherwise;

D_3 = dummy variable, taking the value of unity for farms in Rahimyar Khan district and of zero otherwise;

D_4 = dummy variable, taking the value of unity for farms in Jacobabad and Larkana districts and of zero otherwise;

[1]According to the official statistics, wheat and rice cover more than 52 percent of the total cropped acreage in the Punjab and Sind [7]. A similar percentage share of wheat and rice is found for the sample farms in this study [3, p. 13]. Khan and Maki [4] have also performed tests for efficiency by farm size by using all crop activities on a farm.

D_L = dummy variable, taking the value of unity for large farms (over 12.5 acres) and of zero otherwise;

W = wage rate in rupees per manday (a weighted average of wage rate reported for family and hired labour used);

N = land input (acreage allocated to a specific crop);

K = capital inputs in rupees (the sum of costs of seed, fertilizer, tubewell water, and animal and mechanical power);

M = human labour, which is mandays (in adult male equivalents) of family and hired labour used; and

D_S = dummy variable, taking the value of unity for small farms (12.5 acres or less) and of zero otherwise.

The estimating equations used for examining the relative efficiency of old versus new varieties of wheat and rice are identical, except that a dummy variable, D_N, is substituted for D_L, and a dummy variable, D_O, is substituted for D_S in equations (1) and (2). The dummy variables, D_N and D_O, take the value of unity for observations on the new and old seeds of wheat and rice, respectively. The dummy variables for districts, D_1 to D_4, are introduced to account for agro-climatic differences among these regions. The grouping of districts used here corresponds closely to the distinct agricultural regions of the Indus Basin. Since no dummy variable is used for Nawabshah and Hyderabad districts, the b_0 coefficient represents the intercept of the profit function for these districts.[2]

Equation (1) is termed the profit function and equation (2) is the labour demand function. These equations are estimated by ordinary least-squares (OLS) and, following Lau-Yotopoulos, by the asymptotically efficient method suggested by Zellner [10], both with and without restrictions, detailed below. The assumptions underlying the Zellner method are that the errors comprising e_1 are independently distributed with zero mean and constant and finite variance, and similarly for e_2, but the errors in equation (1) may not be independent of the errors in equation (2).

The data were collected in 1974 from a sample of 732 randomly selected farmers in eight districts of the Punjab and Sind provinces in Pakistan [3]. The regional distribution of the 96 villages (66 from the Punjab and 30 from Sind) was based on each district's share in the provincial acreage of major crops (wheat, rice, cotton, sugarcane and corn). In each of the randomly selected villages, farms were stratified by size into four groups, namely (i) 12.5 acres or less, (ii) over 12.5 acres to 25.0 acres, (iii) over 25.0 acres to 50.0 acres, and (iv) over 50.0 acres. In this study, farms of the first group (12.5 acres or less) are called "small" and all others "large". In this we follow the convention used in other studies on Pakistan's agriculture. The selected districts represent a variety of cropping patterns. However, it should be noted that all areas in the sample have access to water from the canal-irrigation

[2]In view of the regional differences in agronomic conditions in the Indus Basin and on the suggestion of the referee, we have used dummy variables for the regions in our estimations.

system of the Indus Basin. The number of observations used in the estimations are: 175 for old wheat; 579 for new wheat; 102 for old rice; and 206 for new rice.

A word on the measurement of fixed and variable inputs included in the functions is in order. The land input is the sown acreage for a crop in reference, though the size dummies are based on overall farm size. The capital input measures the cost of services of animal labour and farm machinery (owned and hired), the cost of water from owned tubewells or purchased, and the cost of seeds and fertilizer. Land rent is not included in the capital input. The labour input measures in mandays the services of family and hired (casual and permanent) labour. The rate of wage imputed to family labour in each village is derived from the wages paid to hired labour for similar work.

II. THE ESTIMATION RESULTS

In this section, we report and discuss results on differences in efficiency between (i) the new and old seeds of wheat and rice, and (ii) large and small farms in producing the new seeds of wheat and rice. We will also derive estimates of factor elasticities.

We should here clarify the elusive concept of efficiency. The simplest notion of efficiency implies production of maximum output from a given set of inputs: the greater the amount of output relative to inputs, the higher the level of efficiency. However, this concept of efficiency in economics is incomplete without reference to prices. Following Lau and Yotopoulos [5], a useful concept of *economic efficiency* can be stated as follows:

(i) It should account for differences in output among producers from a given set of measured inputs: the component of *technical efficiency*.

(ii) It should account for differences in the ability of producers to maximize profits, i.e. in equating the value of the marginal product of each variable factor to its price: the component of *price efficiency*.

(iii) It should account for differences in prices available to producers.

The UOP function encompasses all these requirements of economic efficiency.

1. New versus Old Seeds of Wheat and Rice

The measurement of differences in efficiency between old and new seeds uses the concept of technical efficiency: variation of output between the old and new seeds with given set of inputs for their production. The estimation results for new versus old seeds of wheat and rice are shown in Table 1. All coefficients have the expected signs, except that in the second and third equations reported for wheat the

Table 1

Results of the Joint Estimation of Profit Functions and Labour Demand Functions (Pooled Data on New and Old Wheat and Pooled Data on New and Old Rice)

Variable (Coeff.)	Old versus New Wheat					Old versus New Rice				
	OLS	Unrest.	1 Rest.	2 Rest.	3 Rest.	OLS	Unrest.	1 Rest.	2 Rest.	3 Rest.
Profit Functions										
(b_0)	4.216 (12.60)	3.943 (15.23)	4.002 (15.45)	4.541 (20.22)	4.614 (19.15)	3.736 (10.74)	3.562 (13.31)	3.606 (13.45)	3.860 (16.88)	3.750 (19.08)
D_1 (b_1)	0.075 (1.12)	0.009 (0.17)	0.010 (0.18)	0.021 (0.41)	0.007 (0.12)	0.340 (4.10)	0.223 (3.51)	0.224 (3.51)	0.281 (5.04)	0.292 (5.71)
D_2 (b_2)	0.520 (10.01)	0.419 (10.46)	0.420 (10.45)	0.427 (10.51)	0.379 (8.67)	0.789 (8.64)	0.490 (7.01)	0.494 (7.03)	0.535 (8.06)	0.534 (8.97)
D_3 (b_3)	−0.502 (−6.22)	−0.445 (−7.15)	−0.446 (−7.14)	−0.382 (−6.25)	−0.490 (−7.55)	0.513 (2.77)	0.297 (2.09)	0.300 (2.10)	0.368 (2.67)	0.386 (3.01)
D_4 (b_4)	−0.616 (−6.39)	−0.455 (−6.12)	−0.456 (−6.12)	−0.388 (−5.29)	−0.210 (−2.70)	0.694 (6.10)	0.621 (7.13)	0.622 (7.11)	0.742 (12.85)	0.734 (13.55)
D_N (b_5)	0.078 (1.65)	0.168 (3.73)	0.094 (2.59)	0.092 (2.50)	0.191 (4.92)	0.304 (5.65)	0.301 (5.87)	0.238 (5.75)	0.235 (5.68)	0.217 (5.62)
lnW (b_6)	−0.134 (−1.21)	0.036 (0.43)	0.035 (0.40)	−0.262 (−5.83)	−0.232 (−5.07)	−0.255 (−1.68)	−0.039 (−0.33)	−0.042 (−0.36)	−0.250 (−10.92)	−0.247 (−10.85)

Continued –

Table 1 – *Continued*

Variable (Coeff.)	Old versus New Wheat					Old versus New Rice				
	OLS	Unrest.	1 Rest.	2 Rest.	3 Rest.	OLS	Unrest.	1 Rest.	2 Rest.	3 Rest.
$\ln N (b_7)$	1.027 (16.05)	0.941 (19.09)	0.942 (19.04)	0.967 (19.47)	0.728 (14.90)	0.694 (11.91)	0.572 (12.83)	0.574 (12.80)	0.565 (12.68)	0.556 (13.22)
$\ln K (b_8)$	0.214 (3.67)	0.237 (5.26)	0.236 (5.24)	0.221 (4.85)	0.272 (5.55)	0.387 (6.44)	0.417 (9.04)	0.416 (8.99)	0.423 (9.16)	0.444 (10.54)
Labour Demand Functions										
$D_N (b_9)$	−0.292 (−4.88)	−0.292 (−4.88)	−0.371 (−7.05)	−0.262 (−5.83)	−0.232 (−5.07)	−0.224 (−7.92)	−0.224 (−7.92)	−0.258 (−11.07)	−0.250 (−10.92)	−0.247 (−10.85)
$D_O (b_{10})$	−0.634 (−5.83)	−0.634 (−5.83)	−0.371 (−7.05)	−0.262 (−5.83)	−0.232 (−5.07)	−0.326 (−8.11)	−0.326 (−8.11)	−0.258 (−11.07)	−0.250 (−10.92)	−0.247 (−10.85)

Note: Unrest. = Unrestricted; Rest. = Restriction(s)

coefficients for the wage term are positive.[3] All estimations indicate that the new seeds are more efficient than the old ones, with the magnitude ranging from 8 to 19 percent for wheat and from 22 to 30 percent for rice. These percentages are simply the coefficient of D_L in the estimating equations.

Sidhu [8, p. 744] reports that efficiency in the production of new wheat in the Indian Punjab in 1967-68 was 48.5 percent higher than in the production of old wheat. This result was obtained from an equation estimated under the restrictions of absolute price efficiency in the labour market and constant returns to scale. In Table 1, our comparable estimates for Pakistan in 1974 show that the new seeds of wheat and rice were more efficient than the old seeds by 19.1 percent and 21.7 percent, respectively. It is impossible to conclude that the substantial difference between our and Sidhu's results on wheat reflects a difference in the two areas studied, since there is also a difference in the periods covered by the two studies. Our results also show that in Pakistan the new seeds of wheat and rice are roughly equally more efficient than the old varieties.

2. Efficiency by Farm Size for New Seeds of Wheat and Rice

The relative efficiency by farm size in producing the new seeds of wheat and rice uses the notions of technical and price efficiencies. The estimation results are given in Table 2. All coefficients have the expected signs, except, as in Table 1, for the coefficients of the wage term in the second and third estimations for new wheat. This coefficient (b_6) becomes negative when it is restricted to be equal to the coefficient in the labour demand function.

To measure the differences in technical and price efficiencies between large and small farms and to determine returns to scale, we use the estimation results of Table 2 in the form of five hypotheses.

Hypothesis 1

There is no difference in technical efficiency between large and small farms. The null hypothesis for this test is: $H_O : b_5 = 0$, and it is tested from results of the Zellner unrestricted estimation.

Hypothesis 2

There is no difference in price efficiency with respect to the labour market for large and small farms, i.e. whether the large farmers pay higher wages than the small

[3]A necessary condition for b_6 to be positive is that either (a) more labour is used at higher wage rates than at lower wage rates, or (b) the wage rate exceeds the value of marginal product of labour. The former condition seems unrealistic, while the latter may be true in our data since family labour is priced at the market wage rate with evidence that hired labour is more productive than family labour [2]. It should also be noted that in the estimation equations without regional dummies, b_6 was positive in the case of rice but negative in that of wheat.

Table 2

Results of the Joint Estimation of Profit Functions and Labour Demand Functions By Farm Size (New Wheat and New Rice)

Variable (Coeff.)	New Wheat					New Rice				
	OLS	Unrest.	1 Rest.	2 Rest.	3 Rest.	OLS	Unrest.	1 Rest.	2 Rest.	3 Rest.
Profit Functions										
(b_0)	4.302	3.907	3.924	4.590	4.319	4.714	4.193	4.330	4.503	4.556
	(9.96)	(11.46)	(11.52)	(14.89)	(13.57)	(10.33)	(11.06)	(11.23)	(12.64)	(13.34)
D_1 (b_1)	0.077	–0.016	–0.016	0.017	0.084	0.219	0.189	0.192	0.240	0.193
	(1.02)	(–0.28)	(–0.27)	(0.29)	(1.37)	(2.44)	(2.55)	(2.53)	(3.81)	(3.37)
D_2 (b_2)	0.509	0.372	0.372	0.402	0.430	0.840	0.618	0.637	0.681	0.541
	(8.50)	(7.89)	(7.89)	(8.49)	(8.80)	(7.46)	(6.62)	(6.70)	(7.74)	(7.35)
D_3 (b_3)	–0.415	–0.453	–0.453	–0.348	–0.402	1.403	0.915	0.957	1.006	0.700
	(–4.79)	(–6.63)	(–6.63)	(–5.38)	(–6.02)	(3.80)	(2.99)	(3.07)	(3.25)	(2.43)
D_4 (b_4)	–0.954	–0.563	–0.564	–0.442	–0.268	0.527	0.563	0.560	0.652	0.698
	(–5.87)	(–4.40)	(–4.40)	(–3.50)	(–2.06)	(4.35)	(5.60)	(5.46)	(10.36)	(11.60)
D_L (b_5)	–0.095	–0.016	–0.039	–0.051	0.178	–0.240	–0.050	–0.188	–0.196	–0.099
	(–1.60)	(–0.30)	(–0.84)	(–1.08)	(4.74)	(–3.16)	(–0.72)	(–2.94)	(–3.07)	(–2.14)
lnW (b_6)	–0.055	0.198	0.198	–0.235	–0.226	–0.127	–0.054	–0.061	–0.220	–0.219
	(–0.41)	(1.88)	(1.87)	(–6.42)	(–6.15)	(–0.76)	(–0.39)	(–0.43)	(–9.55)	(–9.52)
lnN (b_7)	1.039	0.922	0.922	0.937	0.665	0.966	0.748	0.767	0.760	0.663
	(11.76)	(13.25)	(13.25)	(13.30)	(10.50)	(10.93)	(10.21)	(10.27)	(10.19)	(9.48)
lnK (b_8)	0.202	0.242	0.242	0.239	0.335	0.210	0.323	0.313	0.321	0.337
	(2.60)	(3.94)	(3.94)	(3.84)	(5.28)	(2.47)	(4.58)	(4.35)	(4.48)	(4.83)
Labour Demand Functions										
D_L (b_9)	–0.272	–0.272	–0.291	–0.235	–0.226	–0.168	–0.168	–0.224	–0.220	–0.219
	(–6.07)	(–6.07)	(–7.49)	(–6.42)	(–6.15)	(–6.54)	(–6.54)	(–9.61)	(–9.55)	(–9.52)
D_S (b_{10})	–0.350	–0.350	–0.291	–0.235	–0.226	–0.395	–0.395	–0.224	–0.220	–0.219
	(–4.48)	(–4.48)	(–7.49)	(–6.42)	(–6.15)	(–8.82)	(–8.82)	(–9.61)	(–9.55)	(–9.52)

Continued –

Table 2 – *Continued*

Note: Unrest. = Unrestricted; Rest. = Restriction(s) farmers. The null hypothesis for this test is: $H_O : b_9 = b_{10}$, and it is tested from results of the Zellner unrestricted estimation.

Hypothesis 3

There is no difference in technical and price efficiencies of large and small farms. This is a joint test of hypotheses 1 and 2, and the null hypothesis is: $H_O : b_5 = 0$ and $b_9 = b_{10}$. This hypothesis is also tested from results of the Zellner unrestricted estimation.

Hypothesis 4

Maintaining the hypotheses of equal price efficiency with respect to the labour market (Hypothesis 2), large farms exhibit absolute price efficiency. The null hypothesis for this test is: $H_O : b_6 = b_9$, and it is tested from results of the Zellner estimation with one restriction, which is $b_9 = b_{10}$. Note that the same F-values result if we test instead the hypothesis that small farms exhibit absolute price efficiency: $H_O : b_6 = b_{10}$.

Hypothesis 5

Maintaining Hypotheses 2 and 4, the returns to scale are constant. The null hypothesis for this test is: $H_O : b_7 + b_8 = 1$, and it is tested from results of the Zellner estimation with two restrictions, which are $b_9 = b_{10}$ and $b_9 = b_6$.

From the results in Table 3 on relative efficiency by farm size in producing new wheat, the only hypotheses which can be rejected at the 0.05 level of significance are of absolute price efficiency and constant returns to scale. Large and small farms do not differ in technical, price and overall efficiencies. There is evidence of increasing returns to scale. The interpretation of results for new wheat is clouded by the fact that the first four hypotheses are tested using estimations which produced a positive sign for the wage rate variable. Turning to the results for new rice, the only hypothesis which is *not* rejected at the 0.05 level of significance is the hypothesis of equal technical efficiency for large and small farms. All other hypotheses are rejected.

Comparing our results by farm size for new wheat with Sidhu's pooled four-year estimation, we find that both studies conclude that there is no significant difference in either technical or price efficiency, or in the two efficiencies jointly, between large and small farms. Also, the two studies show that the sample farms were not maximizing profits with respect to prices in the labour market. Finally, both studies strongly reject the hypothesis of constant returns to scale, though we find slightly stronger evidence of increasing returns to scale than Sidhu: for the "2 Restrictions" estimation the sum of our elasticity estimates is 1.142 and Sidhu's is 1.045. The results of our study also show that there is no significant difference in

Table 3

Testing of Hypotheses Regarding Relative Efficiency of Large and Small Farms in the Production of New Wheat and New Rice

Hypotheses		Computed F-Ratio (degrees of freedom)	
Maintained	Tested	New Wheat	New Rice
	(1) $b_5 = 0$	0.09 (1,568)	0.52 (1,195)
	(2) $b_9 = b_{10}$	0.74 (1,568)	19.31 (1,195)
	(3) $b_5 = 0$ and $b_9 = b_{10}$	0.77 (2,147)	14.72 (2,401)
$b_9 = b_{10}$	(4) $b_9 = b_6$ (or $b_{10} = b_6$)	64.89 (1,569)	5.74 (1,196)
$b_6 = b_9 = b_{10}$	(5) $b_7 + b_8 = 1$	58.84 (1,570)	8.43 (1,197)

Notes: Critical values $F_{.05}(1, \infty) = 3.84$, $F_{.05}(2, \infty) = 3.00$
Degrees of freedom for denominator for hypothesis 3 differ from others because hypothesis 3 was tested by imposing as restrictions the hypotheses being jointly tested, and then testing to see if restrictions were significant [10, p. 355]. The other hypotheses were tested by computing a Student's t-ratio from the variance-covariance matrix of the coefficients and squaring. The large F-value for hypothesis 4 for new wheat derives from the fact that b_6 is positive and b_9 negative.

relative overall efficiency between large and small farms in producing the new varieties of rice.

The Yotopoulos-Lau [9] results on a total crop production function for Indian farms were marred by a negative coefficient for capital input in the UOP profit function, a problem they attributed to misspecification of the variable. This problem has not appeared in our and Sidhu's studies. However, ignoring the negative coefficient for capital, Yotopoulos and Lau found evidence that large farms were less efficient than small farms, while we have found no difference in efficiency by farm size for new wheat or new rice, testing at the 0.05 level of significance.

3. Factor Elasticities

Assuming a Cobb-Douglas production function, Yotopoulos and Lau [9, p. 217] have shown that indirect estimates of the coefficients of production function can be obtained from the estimated coefficients of the UOP profit function. If we let a_1, a_2, and a_3 represent the production function coefficients for labour, land and capital, respectively, the correspondences between these elasticities and our estimated coefficients in Table 2 are given by:

$$a_1 = b_6/(b_6 - 1) \quad (3)$$

$$a_2 = b_7/(1 - b_6) \quad (4)$$

$$a_3 = b_8/(1 - b_6) \quad (5)$$

The indirect estimates of the input elasticities for old and new seeds of wheat and rice are reported in Table 4.

As shown by Lau and Yotopoulos [6, p. 17], one can calculate the elasticity of demand for labour with respect to the wage rate, land and capital. Using the "3 Restrictions" equation from Table 2, we find that the elasticity of demand for labour with respect to wage rate, (b_6 – 1), is –1.23 for new wheat (–1.37 for old wheat) and –1.22 for new rice (–1.31 for old rice). The elasticity of labour demand with respect to land, (b_7), is 0.67 for new wheat (0.88 for old wheat) and 0.66 for new rice (0.55 for old rice). The elasticity of labour demand with respect to capital,

Table 4

Indirect Estimates of Input Elasticities of Cobb-Douglas Production Functions

Crop		1 Restriction	2 Restrictions	3 Restrictions
New Wheat				
Labour	a_1	–	0.190	0.184
Land	a_2	–	0.759	0.543
Capital	a_3	–	0.193	0.273
$a_1 + a_2 + a_3$		–	1.142	1.000
New Rice				
Labour	a_1	0.057	0.180	0.179
Land	a_2	0.723	0.623	0.544
Capital	a_3	0.295	0.263	0.277
$a_1 + a_2 + a_3$		1.075	1.066	1.000
Old Wheat				
Labour	a_1	0.187	0.277	0.268
Land	a_2	0.813	0.727	0.646
Capital	a_3	0.178	0.157	0.086
$a_1 + a_2 + a_3$		1.178	1.161	1.000
Old Rice				
Labour	a_1	0.008	0.234	0.235
Land	a_2	0.561	0.423	0.420
Capital	a_3	0.346	0.276	0.345
$a_1 + a_2 + a_3$		0.915	0.933	1.000

Note: Results for "1 Restriction" case for new wheat are omitted because the positive coefficient for the wage term in Table 2 yields unrealistic elasticity estimates.

(b_8), is 0.34 for both new wheat and new rice (0.12 for old wheat and 0.45 for old rice). It is important to note that our labour-demand elasticities are approximately one-half as large as those reported by Lau and Yotopoulos. The elasticities of labour demand with respect to land and capital can be interpreted as reduced form elasticities of output with respect to these inputs. These elasticities, which Lau and Yotopoulos refer to as ***mutatis mutandis*** elasticities, are more relevant for some policy decisions than the ***ceteris paribus*** elasticities reported in Table 4. In our sample, the two sets of elasticities do not differ greatly, so the distinction is not as critical.

The results reported in Table 4 indicate a ***higher elasticity*** of labour with respect to output for the new varieties than for old varieties of both wheat and rice. Further, the elasticities of labour with respect to capital are 0.12 for old wheat and 0.45 for old rice. Thus, increasing use of new seeds of wheat and rice and of capital with them will cause problems of labour absorption only in the case of new rice. The elasticity of labour demand with respect to the wage rate is –1.37 for old wheat and –1.31 for old rice. Thus, in producing the new varieties of wheat and rice, a given increase in the wage rate will be less labour-displacing than would be true for old varieties. It should be noted that our estimates of input elasticities are lower for labour and higher for land than Sidhu's. The higher elasticity for land in our study may be explained by the fact that all farms in our sample are irrigated by canal water.

III. CONCLUSIONS

This study confirms previous results indicating that the high-yielding varieties of wheat and rice are more efficient than the old varieties, which is clearly a reflection of their genetic strength and responsiveness to water and fertilizer. In the context of the benefits from the "Green Revolution", it is significant to note that we find no difference in efficiency by farm size in producing the new seeds of wheat and rice. Also, our study suggests that, with the exception of the response of employment to increasing use of capital on new rice, the problem of labour absorption would tend to diminish with increased use of new seeds.

There are some obvious policy implications of this study. We have suggested that large and small farms are equally efficient in producing the new seeds of wheat and rice. At the same time, there is considerable evidence that large farms in Pakistan enjoy preferential access to physical inputs, credit, and markets.[4] The duality of access to income-earning opportunities is sustained by two simultaneous and related forces. Firstly, there exists a high degree of concentration of land ownership and use, which allows the owners/operators of large farms a disproportionate use of market power.[5] Secondly, the bimodal strategy pursued by successive governments has buttressed this power through relatively higher subsidies on inputs

[4]Some of this evidence is highlighted by Khan and Maki [4, p. 67].

[5]A detailed analysis of land concentration has been done by Khan [1].

and outputs. It is likely that without the unequal access enjoyed by large farms they would be far less efficient than small farms. Even if it is true that large and small farms do not differ in relative efficiency, as our study shows, the preferential position of large farms does not serve efficiency and equity in Pakistan. The other related issue of public policy is of employment on farms. While the new seeds seem to create greater demand for labour, the use of more capital on large farms tends to work in the opposite direction in a country in which the problem of labour absorption is indeed critical. One of the major causes of efficiency on small farms is their intensive use of human labour. It is quite obvious then that a policy which breaks up land concentration, and with it the monopoly power of large landowners, would also create increased demand for labour in the countryside.[6]

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[6]Alternative approaches to a land reform policy for Pakistan have been analysed by Khan [1].