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Optimum Resource Utilization in Pakistan's Agriculture

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I. INTRODUCTION

Despite the great promise that increased industrialization has held for rapid growth and labour absorption in the developing countries, industrialization has produced no such results in many of the LDCs. And, yet, the agriculture sector has generally been relegated to a secondary place in the economic plans of these countries.

Pakistan provides an interesting example of one of these developing countries where industrialization and development were considered synonymous at one time and economic policies were geared to bringing about rapid industrialization. However, at the commencement of the Sixth Five-Year Plan, Pakistan had achieved an annual growth rate of about 4 percent over the 1955–82 period, yielding a paltry one-percent increase in per capita income, a gain not worth cheering about. What went wrong? Were the policies ill-conceived? Was rapid industrialization really the same as development? Was the promise illusory? These and similar other questions are generally asked. But one is hard put to come up with *satisfactory* answers, even though there is no dearth of answers.

Turning to the agriculture sector – which cannot be neglected for too long, especially when this sector contributes 30 percent to GDP, currently employs approximately 53 percent of the labour force, and provides the basis of most of the manufacturing activity – agriculture-oriented growth has also had its heyday, especially during the Third Five-Year Plan, and still enjoys the support of many a policy-maker.

It seems that in Pakistan economic policy concerning the two sectors (agriculture and industry) has followed the motions of a pendulum. At one time it was geared to promoting industrialization through various tax concessions, liberal trade and credit policies, subsidies and an overvalued exchange rate. The agriculture

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sector, it was thought, would look after itself even in the face of unfavourable terms of trade. Then it was time to look after the resulting stagnant agriculture sector. Increased imports of tractors, improved seeds, fertilizers, all subsidized, would make up for what agriculture had lost through years of neglect. As in the case of industry, where technology and equipment were imported without reference to factor intensities prevailing in Pakistan, the same seemed to be happening in agriculture. There was no time to consider whether scarce resources were being allocated efficiently, especially in a country which could ill-afford to do otherwise.

This paper examines the neglected resource-allocation problem in Pakistan's agriculture at the aggregate level.[1] Optimum level and combination of resources are estimated that would have (i) minimized the cost of production, and (ii) made marginal value products for all resources equal to their earnings in alternative uses. The optimum resource allocation analysis is oriented to the 1956–1985 period rather than to the future. This study is based on the assumption that resources are mobile and that knowledge of both cost-minimizing and equilibrium resource allocation is useful for public policy.

The remainder of this paper is organized as follows. The method employed to obtain elasticity estimates is discussed in Section II. Elasticity estimates are obtained for five input-groups by decades since 1956 and are presented in Section III. These estimates are subsequently used to construct a series of aggregate production functions, one for each decade. Section IV uses the production functions to estimate minimum-cost input levels for specified outputs for each decade. Section V is devoted to computing equilibrium output and resource levels for the 1976–1985 period and comparing them with their actual levels, thus determining any excess output and resource use. Section VI concludes this paper with the salient findings and limitations of the study.

II. THE ESTIMATION METHOD

The traditional approach for obtaining production elasticity estimates is by specifying and estimating an aggregate production function (in linear or log-linear form) through direct least squares or some variant thereof. The problems of identification and multicollinearity amongst the "independent variables" leads to unreliable coefficient-estimates. A second approach, generally known as Klein's Factor Share Method, uses factor shares as production elasticities and is based on the dubious assumption that economic equilibrium prevails. Therefore, to use production coefficients derived in such a manner to determine optimum resource allocation and output is anachronistic.

[1]Work has been done at the micro level. For example, Khan and Maki [6] have tested relative efficiency of large and small farms, using survey data for Punjab and Sind.

The paper combines favourable features of the two approaches outlined above.[2] The factor share is defined as the ratio of expenditures on an input to the value of output. If economic equilibrium prevails then the factor share and elasticity of production are equal as shown below. The factor share is, by definition,

$$F_i = \frac{P_i X_i}{P_y Y} \quad \ldots \quad (1)$$

In equilibrium, the marginal product of X_i is equal to the input-output price ratio as given in:

$$\frac{\partial Y}{\partial X_i} = P_j/P_y \quad \ldots \quad (2)$$

When Equation (2) is multiplied by $X_i \, Y^{-1}$, the result obtained is by definition the elasticity of production, as Equation (3), and Equations (1) and (3) are equal

$$E_p = \frac{\partial Y}{\partial X_i} \cdot \frac{X_i}{Y_i} = \frac{P_i X_i}{P_y Y} \quad \ldots \quad (3)$$

In order to avoid the equilibrium assumption, the factor share is taken as a beginning estimate of productivity in this study. The assumption is then made that the employment of a factor (expenditure on the factor) tends towards an equilibrium level as indicated by

$$F_t - F_{t-1} = g\,(E_t^* - F_{t-1}) \quad \ldots \quad (4)$$

where E_t^* is the current equilibrium factor share and g is the proportion of adjustment to the equilibrium made in one time-period. Adjustment to equilibrium is not instantaneous because of risk, uncertainty, technical restraints, institutional rigidities, and psychological resistance to change. The above model thus depends upon this lag and the profit-maximization assumption. If E^* is relatively constant over the time period of analysis, the model may be an apt description of reality. However, if E^* is varying due to technological change, the estimate E^* will be an average for the period and g will be a measure of the rate of adjustment to a *moving* equilibrium.

Consider first the likelihood of a changing E^*. One of the following two alternative methods could be used to account for such an event:

[2]The method outlined is very similar to the one used successfully by Tyner and Tweeten [12] in estimating production elasticities for U.S. agriculture.

(i) estimation of E_t^* for short periods during which E^* is thought to be relatively constant; or

(ii) estimation of a parameter describing the change.

To estimate changes in elasticity, the following equation is used which is a variation of Equation (4):

$$F_t - F_{t-1} = g(E' + \sum_i^2 d_i D_i - F_{t-1}) \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

where D_1 = 1 in each year between 1956 and 1965; zero elsewhere; and

D_2 = 1 in each year from 1966 to 1975; zero elsewhere.

Equation (5) allows E_t^* to vary between decades depending on the d_i values. The estimates are $E^*_{1956-1965} = E' + d_{1956-1965}$ etc., with E' being the estimate for the 1976–1985 period.

The second method is based on the hypothesis that the adjustment rate is not constant for a particular factor X_i but depends on some other variables, such as relative prices, income levels, expectations, etc. Assuming that E_t^* is constant, such a hypothesis could be tested by

$$F_t - F_{t-1} = (g' + h P_{t-1})(E_t^* - F_{t-1}) \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

where the rate of adjustment g is a linear function of P (relative prices or other relevant variables).

The basic model – Equation (4) – was presented without the assumption of a normally distributed error term e_i. The above equation tends to possess an auto-correlated error term when estimated by ordinary least squares. As a result, coefficient estimates tend to be inefficient.

If autocorrelation is suspected, the autocorrelated term is added to Equation (4) to get

$$F_t - F_{t-i} = g(E_t^* - F_{t-i}) + U_t \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

Autocorrelation can be corrected by using the Cochrane-Orcutt technique.

III. ESTIMATION OF PRODUCTION ELASTICITIES

Factor shares were calculated for the following five input categories:

1. Land
2. Labour
3. Tractors
4. Tubewells
5. Draught Animals

These inputs pertain strictly to the agriculture crop sector. Expenditures on these inputs, such as on land and machinery, are the depreciation and opportunity (rent-interest) charge necessary to maintain these inputs at the current level. Family labour is assumed to be paid the hired-labour wage rate. All expenditures are in 1959-1960 million rupees. The input series were obtained from Pakistan Economic Survey 1985-1986 and expenditures were calculated on the basis of the works of Wizarat [16] and Naqvi *et al.* [9]. Inputs were valued at actual or opportunity cost, and no input took a residual return.

The adjustment equations given in the preceding section were estimated in both linear and log-linear forms, using ordinary least squares and auto-regressive least squares. No evidence was found for a changing rate of adjustment, Equation (6). On the other hand, E_t^* obviously has changed considerably for all inputs over the 1956–1985 period, making Equation (5) a highly plausible hypothesis.

Elasticity estimates obtained for the five input categories based on Equations (5) and (7) corrected for autocorrelation are given in Table 1. Selection of Equation (7) over Equation (5) was made where the estimate of β (the autocorrelation co-efficient) was significant. The remaining equations in Table 1 were selected, using the criterion of a higher adjusted R^2. The direction of changes in estimated elasticities over time seems consistent with actual observation, i.e. increases for tractors and tubewells and decreases for labour, land and draught animals. Current magnitudes of individual estimates may be somewhat misleading because of the fact that they are 10-year averages. For example, if the productivity of tractors is increasing, the

Table 1

Selected Estimates of Production Elasticities by Decades

Input	Equation[a]	Adjustment Rate[b] (g)	Production Elasticities 1956–1965	1966–1975	1976–1985
1. Land	LS(0)	0.146	0.666	0.491	0.433
2. Labour	ALS(0)	0.439	0.502	0.426	0.414
3. Tractors	ALS(L)	0.143	0.0003	0.005	0.006
4. Tubewells	ALS(L)	0.301	0	0.012	0.018
5. Draught Animals	ALS(0)	0.297	0.041	0.060	0.037
Sum of Elasticities			1.21	0.99	0.91

Note: [a](0) is original and (L) is data in logarithms. LS stands for estimates of Equation (5) and ALS denotes estimates corrected for autocorrelation.

[b]Proportion of [illegible] yearly.

1985 value would be greater than .006. Likewise, the value for labour would be less than 0.414.

The sums of elasticities during the three periods are also given in Table 1, but the lack of certainty about all inputs having been included in value added precludes the drawing of any conclusions regarding returns to scale in agriculture. Table 1 also includes the estimated rates of adjustment. The adjustment rate for land is low for obvious reasons, given a fixed land base. Similarly, it is low for tractors (0.143), as they were mostly imported before and there used to be a considerable lag between the need being felt and the tractors being put into operation. Labour has the highest adjustment rate (0.439), indicating some degree of flexibility in hiring labour.

It is hypothesized that the imputed elasticities of production in Table 1 express input-output relations in a Cobb-Douglas type of function:

$$Y = A X_i^{b_i} X_2^{b_2} \ldots\ldots\ldots X_5^{b_5} \qquad \ldots \qquad \ldots \qquad \ldots \qquad (8)$$

where Y is output and the X_i s are inputs, with the b_i s representing the corresponding elasticities of production.[3] The function was selected for this analysis because of its frequency of occurrence in the literature and its relative simplicity of use, especially since a number of estimates of the b_i s are already available for comparison. This function also affords relative ease of manipulation for determination of the items studied in this paper. It is necessary, however, to assume that the elasticities are independent of the level of factor use, which places a limitation on the usefulness of the elasticities for sizeable changes in input levels.

The constant term A in Equation (8) has yet to be determined. Two alternative ways may be used for its estimation, depending on whether the error is assumed to be additive or multiplicative. In the additive case, A may be estimated by considering $X_i^{b_1} X_2^{b_2} X_3^{b_3} X_4^{b_4} X_5^{b_5}$ as one variable R. Using constant rupees data for Y and the Xs the relation

$$Y = aR + u \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad (9a)$$

may be estimated by the least-squares method. If the error is assumed to be multiplicative, the function becomes

$$Y = aRu \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad (9b)$$

[3]The formula $Y = \sum_{i=i}^{n} \frac{Y}{\partial X_i} \cdot \frac{X_i}{e}$ imputes the total output to the respective inputs $X_i, \ldots\ldots\ldots, X_n$ where e is the degree of homogeneity of the production function. Two approaches are feasible to impute to factors the entire output over a period of time. One is to adjust upward the quantity series X_i for changes in productivity of the factor as technological changes occur, and to leave dY/dX_i unchanged. The second approach, which was used in this paper, is to leave quantity unadjusted for increased productivity, and to reflect increased productivity in the marginal product or elasticity of production through the method described in Section II.

and a is estimated from

$$\text{Log } Y = \text{Log } a + \text{Log } R + \text{Log } u \qquad \ldots \qquad \ldots \qquad \ldots (9c)$$

The equation with the higher R^2 can be selected. On the basis of this criterion, the additive case, Equation (9a), was the more plausible assumption. The as obtained on the basis of Equation (9a) were as follows:

1956–1965 : 0.3336
1966–1975 : 2.6728
1976–1985 : 5.9145

Combining the elasticity estimates from Table 1 and the calculated values of a above in the Cobb-Douglas framework provide estimates of the production function for three 10-year periods.

IV. MINIMUM-COST INPUT LEVELS

After the parameters of the production function, as specified in Equation (8), had been estimated, they were used to determine minimum-cost input levels for specified output levels as follows. The total-cost equation is

$$TC = \Sigma P_i X_i \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad (10)$$

That is, total cost is the sums of input quantities times their respective prices.[4] To minimize total costs, subject to production of a specified output Y^*, the production function constraint is added. The resultant Lagrangian is

$$L = \Sigma P_i X_i + \lambda (Y^* - aX_1^{b_1} \ldots\ldots X_5^{b_5}) \qquad \ldots \qquad \ldots \qquad (11)$$

where λ is the Lagrangian multiplier. The partial derivatives of the Lagrangian with respect to $X_i, \ldots\ldots, X_5, \lambda$ are then equated to zero.

$$\frac{\partial L}{\partial X_i} = P_1 - a\lambda b_1 X_1^{b_1 - 1} \ldots\ldots X_5^{b_5} = 0 \qquad \ldots \qquad \ldots \qquad (12)$$

$$\frac{\partial L}{\partial X_2} = P_2 - a\lambda b_2 X_1 X_2^{b_2 - 1}, \ldots\ldots X_5^{b_5} = 0 \qquad \ldots \qquad \ldots \qquad (13)$$

$$\partial L/\partial X_5 = P_5 - a\lambda b_5 X_1^{b_1} \ldots\ldots X_5^{b_5 - 1} = 0 \qquad \ldots \qquad \ldots \qquad (16)$$

$$\partial L/\partial \lambda = Y^* - aX_i^{b_1} \ldots\ldots X_5^{b_5} = 0 \qquad \ldots \qquad \ldots \qquad \ldots \qquad (17)$$

[4]Since the inputs are measured in rupees, the prices of these inputs are assumed to be Re 1.

Minimum-cost input levels to produce the average outputs of the three periods were determined by first taking logs of Equations (12) to (17) and then solving the system of simultaneous linear equations.

Optimal input combinations were derived for the following situations:

A. All inputs were assumed to be variable
B. Land (X_l) was held constant; other inputs were variable
C. For 1976–1985 only, average output was increased to 1.05 $\bar{Y}$, 1.10 $\bar{Y}$ and 1.15 $\bar{Y}$ under the following conditions:
   (i) land fixed, other inputs variables,
   (ii) all inputs variable.

For situation A, input combinations computed from the "equilibrium" elasticity estimates are given in Table 2. Actual averages for the respective periods are included for comparison.

Looking first at land in Table 2, it is estimated to have been used in excess of minimum-cost-inputs by 58 percent, 7 percent, and 2.5 percent for the 1956–1965, 1966–1975 and 1976–1985 periods, respectively. Labour seems to have been hired in excess by approximately 33 percent of the minimum cost during the 1956–1965 period but was utilized 2 percent and 3.8 percent less that what minimum-cost would have dictated for the 1966–1975 and 1976–1985 periods, respectively. The results indicate that tubewells have been optimally utilized for the latter two periods. Draught animals were used in excess by 37 percent during the 1956–1965 period, but their services were utilized 30 percent less than required by optimal use considerations for the 1966–1975 period. During the 1976–1985 period, draught animals were being utilized more or less optimally, their use being only 2.5 percent less than the optimal use. The results strongly suggest that tractors have always been used more than indicated by minimum-cost levels. Their excess was approximately 8 times the minimum-cost level during the 1956–1965 period, 58 percent in the 1966–1975 period, and 4.25 times the minimum-cost level for the 1976–1985 period.

We, therefore, see that continual increases in investment in tractors during the 1956–1985 period have led eventually to less than optimal uses of labour, the primary displacement effect being on the use of draught animals from 1966 to 1975, whose use has tended to the optimal since then. Increased use of tractor is also coupled with excessive use of land (from 1976 to 1985). At the aggregate level, resources were used in excess by 148 million rupees (in terms of the 1959-1960 rupees) during the 1976–1985 period, reflecting mainly excessive investment in tractors.

Table 2

Minimum-Cost Levels of Inputs Required for Average Actual Output by Decades: 1956–1985 (All-Inputs Variable with Average Inputs for Comparison)

(Million 1959-60 Rupees)

Item	Level[a]	Period 1956–1965	1966–1975	1976–1985
1. Land	M	2479.99	4141.73	4973.41
	A	3914.65	4436.92	5100.22
2. Labour	M	1849.89	3592.38	4755.04
	A	2452.30	3511.25	4584.15
3. Tractors	M	1.64	42.18	64.32
	A	13.17	66.68	273.85
4. Tubewells	M	b	98.69	207.89
	A	13.80	102.29	203.96
5. Draught Animals	M	228.80	505.73	424.88
	A	314.20	356.98	414.19
6. λ[c]		1.0994	1.0348	1.0372
Average Output		5006.10	8155.80	11073.90

[a]M represents minimum-cost levels; A is the actual average for the period indicated.

[b]No elasticity estimate was obtained for tubewells for 1956–1965. In various formulations, the elasticity estimate frequently switched signs and generally was not significantly different from zero.

[c]λ represents the amount of cost associated with a unit increase in output.

The preceding minimum-cost levels of inputs were determined by assuming that all inputs were perfectly elastic in supply. Especially for land, this assumption seems implausible, since the land base is fixed and increases can occur only through land improvement practices which bring water-logged or saline or unlevelled marginal land under the plough, thereby leading to increasing rents for infra-marginal land.

It would have been desirable to have an estimate of productivity for land and improvements separately, though this was not practical. Therefore, under situation B, the land input was held at actual levels. The resulting estimates are presented in Table 3.

Looking at the estimates in Table 3, we see the use of labour tending towards an optimum level being used in excess by 132 percent over minimum costs during the 1956–1965 decade. Labour use was 1.3 percent under the estimated optimum by the 1976–1985 period. Tubewells have always tended to be utilized at optimum levels. Expenditures on draught animals were considerably in excess (140 percent) during the 1956–1965 period but were being utilized optimally by 1976–1985, having been 32 percent in excess over the 1966–1975 period. As brought out in Table 2, expenditures on tractor use have been substantially above optimal levels, especially during the 1976–1985 period, when they were more than 4 times the optimum expenditures. Looking at the immediately preceding period of 1976–1985,

Table 3

Estimated Minimum-Cost Levels of Inputs Required for Average Actual Output by Decades: 1956–1985; Land Fixed, Other-Inputs Variables, with Average Inputs for Comparison

(Million 1959-60 Rupees)

Input	Items[a]	1956–1965	1966–1975	1976–1985
1. Land	(Fixed)	3914.65	4436.92	5100.21
2. Labour	M	1056.48	3350.95	4642.46
	A	2452.30	3511.25	4581.15
3. Tractors	M	0.94	39.34	62.77
	A	13.17	66.88	273.85
4. Tubewells	M	b	92.35	202.96
	A	13.80	102.29	203.96
5. Draught Animals	M	130.67	472.10	414.88
	A	314.20	356.98	414.19

[a]M is minimum-cost level; A is the actual average for the period indicated.

[b]No elasticity estimate was obtained for tubewells for 1956–1965.

there appear to have been excess resources committed to agriculture by about 150 million rupees (in terms of 1959-1960 rupees). Increased mechanization over and above minimum-cost levels have substituted for labour. The results in Table 3 are not significantly different from those in Table 2. Where land is variable, the excess use of factors amounts to 147.83 million rupees (in 1959-1960 rupees) in contrast with 150 million rupees when land is held at actual levels. Some substitution of machinery for land is indicated by this.

One of the goals of public policy has been to encourage increases in agricultural production for reasons of self-sufficiency and greater exports. Under situation C, we arbitrarily select levels of 5, 10 and 15 percent increased production for demonstrating adjustments in input use to increased production by stated amounts. The criterion used is that of minimization of production costs to farmers. Minimum-cost input levels are calculated for outputs of 105 percent, 110 percent and 115 percent, respectively, of the 1976–1985 average. Table 4 shows the solution and actual values of inputs under both cases, viz. when land is fixed and when it is variable. Looking first at the case of fixed land, we find that expenditures on labour,

Table 4

Minimum-Cost Levels of Inputs for Output Levels Increased 5, 10 and 15 Above Actual Average, 1976–1985

(Million 1959-60 Rupees)

Input		Actual Average Input	Percent of Average for 1976–1985: 100	105	110	115
1. Land	F[a]	5100.21	5100.21	5100.21	5100.21	5100.21
	V		5100.21	5241.80	5538.62	5801.08
2. Labour	F	4581.15	4642.46	5133.28	5673.15	6231.05
	V		4642.46	5011.55	5295.43	5546.38
3. Tractors	F	273.85	62.77	69.41	76.71	84.25
	V		62.77	67.79	71.63	75.02
4. Tubewells	F	203.96	202.96	224.42	248.02	272.41
	V		202.96	218.98	231.53	242.50
5. Draught Animals	F	414.19	414.88	458.75	506.99	556.85
	V		414.88	447.82	473.19	495.62

[a]F is minimum-cost input levels with land fixed at actual levels.
V is minimum-cost input levels with all inputs variable.

tubewells and draught animals would have had to increase by 12 percent, 10 percent and 11 percent, respectively, over their actual average levels to achieve an output increase of 5 percent over what was produced on average during the 1976–1985 period. There would have been no need for additional expenditures on tractors as they would have been still in excess by 204 million rupees (in terms of 1959-1960 rupees). At the aggregate levels, if all inputs except land had been combined in optimal proportions so that costs were minimized, additional expenditures of 412.71 million rupees (in 1959-1960 rupees), or 7.5 percent increase, would have been needed to augment production by 5 percent over the actual average level during the 1976–1985 period.

Letting land vary leads to reduced requirements of other inputs. However, at the aggregate level, approximately the same amount of additional expenditure as above would have been needed to achieve a 5-percent increase in production, although the input mix would be different.

To expand agricultural output by 15 percent over actual average production in the 1976–1985 period, given a fixed land base, would have necessitated increases of 36 percent, 34 percent and 34 percent in expenditures on labour, tubewells and draught animals over actual average levels, respectively. Expenditures on tractors would still be in excess by 125 percent of minimum-cost expenditures. Given an optimal mix, increased expenditures of 16 percent on inputs would have been required. If land were allowed to vary, increased expenditures of 15 percent would have been needed (indicating roughly constant returns to scale).

V. EQUILIBRIUM OUTPUT AND RESOURCE LEVELS

The previous section emphasized the findings of optimum input combinations under the conditions in which the level of output was specified. No mention has been made of the impact of changing output-prices on output and vice versa. It would be interesting to note the effect of output price on farmers' demand for inputs and the resultant effect on output.

In other words, we would like to know what output could be expected if the use of inputs was at equilibrium, and what would the effect be of changing levels of prices received on output, i.e. what is the supply curve? The analysis is confined to the 1976–1985 period and input supply (except land) is assumed to be perfectly elastic. This implies that changes in input and output levels have no perceptible influence on input prices.

The supply function which is based on equilibrium factor use is derived as follows. The competitive equilibrium condition for factor use is that the value of marginal product of a factor is equal to the factor price, or $MPP_i = P_i/P_y$. Therefore, the partial derivatives of the production function with respect to the various inputs are set equal to P_i/P_y. Adding the production function to the system and solving simultaneously gives the desired values of X_i and Y for a given P_y. The system can be re-solved to generate different values of Y by varying P_y, thus generating a supply curve. The intersection of an aggregate demand with the supply curve then will indicate the output and price level necessary for production-consumption equilibrium and factor-use equilibrium.

The S line in Figure 1 is the supply curve, based on equilibrium factor use, showing the calculated values of Y for different levels of P (index of agriculture prices; 1959-1960 = 100), given $MPP_i = P_i/P_y$. Since P_y is initially Re 1 per unit (output is in constant rupee-value terms), the system of simultaneous linear equations was solved with P_y = Rs 0.75, Rs 0.80, ..., Rs 1.20. These prices were then converted to the agriculture price index, with Re 1 corresponding to the average index for the period (417.14).[5]

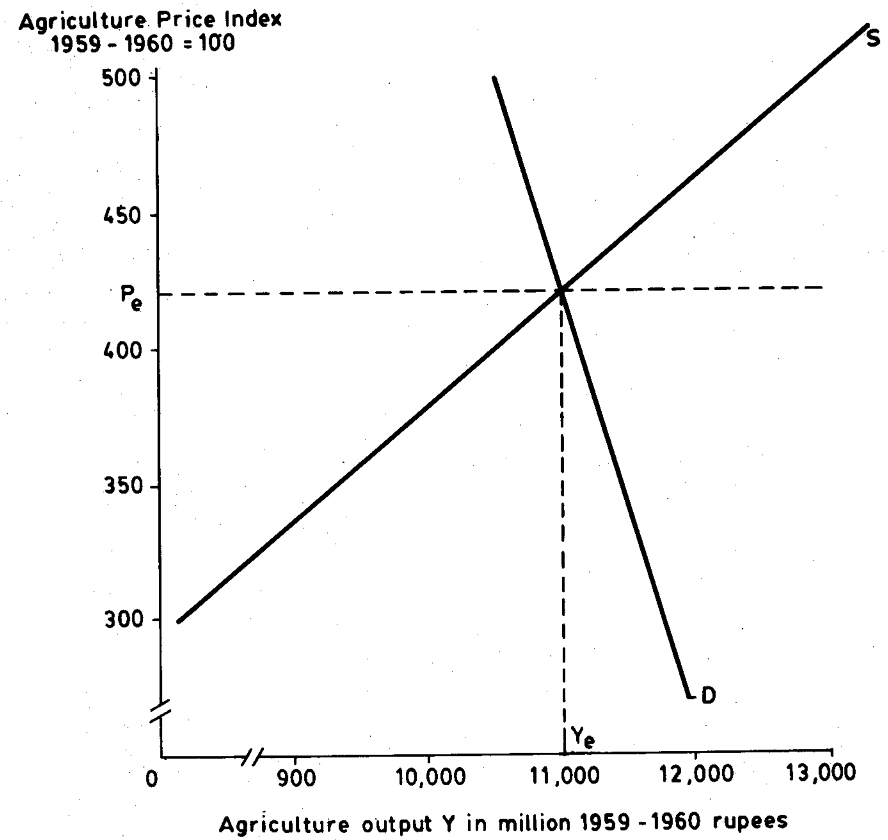

Fig. 1. Aggregate Agriculture Demand and Supply, Showing Equilibrium Price P_e and Output Y_e for the 1976–1985 Period

[5] The supply equation is $Y = 988.5629 + 23.8536\ P_y$ measured at factor cost. It needs to be adjusted to market prices. I am thankful to Dr Aftab Ali Syed for pointing this out.

The demand curve was estimated for the 1974–1985 period by ordinary least squares where the agriculture price index and constant-rupee GDP at market prices were the independent variables.[6] Intersection of the *D* and *S* curves is at approximately $Y_e = 11043$ million rupees and $P_e = 422$.

Table 5 contains the equilibrium input-levels associated with equilibrium output-price and quantity in Figure 1. At the indicated input-levels, all resources

Table 5

Estimated Equilibrium Input Levels for 1976–1985[a]

(Million 1959-60 Rupees)

Input	Actual Average Input	Equilibrium Input	Actual Input as Percentage of Equilibrium (%)
1. Land	5100.21	5100.21	100
2. Labour	4581.15	4616.0747	99
3. Tractors	273.85	62.4146	439
4. Tubewells	203.96	201.8046	101
5. Draught Animals	414.19	412.526	100.4
Total Volume	10573.36	10393.03	102

[a]See text and Figure 1 for definition of equilibrium. Land is fixed at the 1976–1985 average level. All inputs except land are assumed to be variable and perfectly elastic in supply and are valued at opportunity cost levels.

[6]The demand equation estimated by ordinary least squares is

$$Y = \underset{(2.92)}{4459.585} + \underset{(2.16)}{0.1616}\ GDPMP - \underset{(-1.01)}{6.9660}\ P$$

$$\bar{R}^2 = 0.83 \qquad \text{D. W. Statistics} = 1.77$$

where *GDPMP* is gross domestic product at market prices in million rupees in terms of 1959-1960 rupees. The numbers in parenthesis underneath the coefficients are their associated *t*-values. The average value of *GDPMP* for the 1976–1985 period was 59500.7 million rupees. Substituting this value into the estimated equation, the following equation for the demand curve was obtained:

$$Y = 13979 - 6.966\ P$$

would have received earnings at their opportunity cost, and the total cost of producing the equilibrium output would have been minimized. Tractors were in excess supply by 439 percent. It will be noticed from Table 5 that the use of all inputs, except tractors, is very close to their equilibrium levels – labour being used by 1 percent less than the equilibrium level, whereas expenditures on tubewells were 1 percent more. The use of draught animals is virtually at equilibrium. The equilibrium output is 2/10ths of 1 percent less than actual output (approximately 31 million rupees in terms of 1959-1960 rupees). The total output volume is reduced from the actual Rs 10573 million to the equilibrium Rs 10393 million – an excess of 2 percent of actual over equilibrium (a difference of approximately 180 million rupees in terms of 1959-1960 rupees). It is useful to point out that tractors are in excess by 211 million rupees and labour is underutilized by approximately 35 million rupees. If 35 million rupees of excess expenditures on tractors was shifted to labour, net excess expenditures on the two inputs would be 176 million rupees which is fairly close to the excess amount spent on all inputs.

We conclude this section by noting that equilibrium average output for the 1976–1985 period is virtually the same as actual average output. It could have been produced by a recombination of inputs into the least-cost mix, thus saving 180 million rupees (in terms of 1959-1960 rupees).

VI. CONCLUSIONS AND LIMITATIONS

The conclusions and limitations of this study are as follows.

1. Adjustment to a minimum-cost input combination to produce actual average 1956–1965, 1966–1975 and 1976–1985 outputs in the agriculture crop-sector would have reduced input costs (in 1959-1960 rupees) by 2147.8 million rupees (32 percent), 93.39 million rupees (1.1 percent), and 147.83 million rupees (1.4 percent), respectively. These results were based on variability of all factors. Employing a more realistic assumption, viz. fixing land at actual levels, the corresponding reduction in input costs would have been 1605.75 million rupees (24 percent), 82.66 million rupees (1 percent), and 150 million rupees (1.42 percent), respectively.
2. To increase output by 5–15 percent of actual average output that prevailed during the 1976–1985 period would have required substantial increases in individual input levels, except for tractors. Whether land was fixed or variable did not have a significant effect on these findings. Thus, the path to rapid increases in agriculture output might be in improved seeds, fertilizer availability, better water management, and agricultural extension services.

3. Adjustment of farm resources to an equilibrium level, with all variable inputs earning on opportunity cost return would have entailed a reduction of 180 million rupees (in terms of 1959-1960 rupees), or 2 percent of the actual input value. This was entirely the cost of a non-optimal input-mix.
4. Though labour was being used considerably in excess of minimum-cost input levels during the 1956–1965 period, its use tended towards optimality, and by 1976–1985 it was being used less than required by minimum costs, indicating labour displacement due to tractorization. Tubewells and draught animals were being used optimally during the 1976–1985 period, though they were used sub-optimally during the 1956–1965 period.
5. The finding that tractors were in excess supply has been quite robust in all situations in this study. This excess continued to increase and, by 1976–1985, they were being used approximately four times the optimal requirement. It is quite possible that they are used for purposes other than those of the production of agricultural crop, a matter which needs further investigation. These findings are based on the Cobb-Douglas Production Function. To lend further credibility to the results, analysis based on other types of production functions, such as CES and translog functions, is also needed.
6. The input and output series and their prices in 1959-1960 were taken from the *Pakistan Economic Survey 1985-1986*, Wizarat [16], and Naqvi *et al.* [9]. Expenditures were calculated by using information contained in these works. It was entirely beyond the scope and resources of this study to construct more accurate and meaningful series, even if such an effort was thought necessary.
7. The analysis has been based on the assumption that farmers minimize cost or act as if they do. Given the considerable risk and uncertainty in the agricultural sector, risk minimization might be a more plausible assumption and it is quite possible that the results might be different. Future studies may want to test alternative assumptions about farmer behaviour.

The above analysis can serve as a guideline for public policy (which, historically, has tended to fluctuate between rapid industrialization and rapid growth in agriculture) by indicating the magnitude of resource adjustments needed to achieve economic equilibrium, and the economic costs of maintaining non-optimal resource levels and combinations in agriculture. The analysis shows that output responds fairly rapidly to incentives in terms of higher prices and the agricultural crop sector is quite efficient. It also provides a method that might be used at the firm or industry level to determine production parameters, various important elasticity measures, and optimum resource allocation.

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Comments on "Optimum Resource Utilization in Pakistan's Agriculture"

This study is a welcome addition to the meagre literature on Pakistan's agriculture. It has several important features worth noting here. For one thing, it uses the aggregate time-series data on the issue of resource allocation, whereas other studies have been based on the micro-level cross-section data collected from field surveys. It is also novel in that it applies a partial-equilibrium approach to test the hypothesis of optimal allocation of resources to crop production in Pakistan for a period of thirty years. It derives several estimates of supply and demand elasticities for major inputs. Another major contribution of this paper is that it identifies data problems on key variables, particularly in the use of aggregate data.

The policy results of this exercise are no less interesting. Firstly, it reinforces the importance of seed, fertilizer, water management, and agricultural extension as major factors contributing to the growth of crop output. Secondly, it shows that people respond well to changes in the price of output, especially their use of labour. Thirdly, a general conclusion is that land, labour and tubewells have been used optimally. Tractors have been the only exception, used four times the optimal requirement. The role of tractors may have been biased because of the exclusion of the value added by them to activities other than crop production. It is interesting that the total cost of the non-optimal mix of inputs is only 2 percent of their actual value. The author's simulation exercise on input requirements for expanding the crop output in the future points to some interesting options.

A major underlying assumption of the author is that people (farmers) maximize profits. He has not explored the alternative assumption that farmers in Pakistan may have been minimizing risk! Granted his assumption about profit maximization, why does he not use a profit-function approach and estimate directly the factor-demand and product-supply elasticities. He does not explain the reasons for the indirect estimates by the Cobb-Douglas production function. Lau and Yotopoulos have clearly shown that direct estimates are far more efficient and reliable than the indirect estimates derived by a step-wise approach adopted by the author in the paper.

The author gives no explanation for the somewhat arbitrary split of the adjustment due to technical change into two periods. Why does he choose the decades of (a) 1956–66, and (b) 1966–75? In view of the strong evidence of instability in the output level from year to year, the author should have first determined the value of crop output.

One of the serious problems with the study is its exclusive reliance on the input indices built by Shahida Wizarat. The paper does not tell the reader if any adjustments were made, particularly as some of the indices are seriously at fault. The overestimation of livestock and underestimation of tubewells and tractors are only two of the serious problems. The other equally serious problems have to do with the values of land rents and wage rates from a small sample in the Punjab. The author says nothing about the basis on which he extrapolated the estimates made by Wizarat. What, if any, adjustments has he made for the period after 1979-80?

The author's statements on the substitution of land by tractors is somewhat puzzling because he also states that "increased use of tractors has also led to excessive use of land." How has labour substituted for land, as he states at another place in the paper? We need some intuitively reasonable explanations for these rather optimistic substitutions of land by tractors and labour. The tractor-labour substitution is always a strong possibility. The tractor-land substitution is possible if cropping intensity goes up sharply as a result of tractor use. The labour-land substitution has almost no appeal to intuition.

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