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TECHNICAL CHANGE IN PAKISTAN'S AGRICULTURE: 1933-54 TO 1977-78

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TECHNICAL CHANGE IN PAKISTAN'S AGRICULTURE: 1953-54 TO 1977-78

The role of total factor productivity as a factor contributing to economic growth is quite controversial in the literature. Work on total factor productivity started with the pioneering works of Abramovitz [1], Kendrick [19, 20] and Solow [33], followed by Denison [7] Griliches [12, 13] Jorgenson and Griliches [16], Tang [35] and others. While Abramovitz, Kendrick and Solow attach great importance to total factor productivity as a factor contributing to growth, Jorgenson and Griliches observe that the unexplained residual which is labelled as technical change may be due to measurement errors, changes in the quality of inputs, economies of scale etc. Much of this controversy is due to the fact that the former group of economists include only the conventional inputs, with the result that the contribution of the unconventional inputs is reflected in a large residual, while Jorgenson and Griliches include non-conventional inputs like education, research and extension etc. as separate variables thus reducing the size of the residual.

Kendrick's total factor productivity index for the U.S. agriculture for the period 1929-66 (using real gross product) increased from 52.6 to 126.6 (1958=100) [19]. This increase in productivity is attributed to the growth of "real stock of intangible capital" which helped to improve the quality of the factors of production. Kendrick discusses expenditures on research and development, education and training and medical care as equivalents to tangible capital since they help to increase output in the future. Some other causes of increase in productivity are changes in economic efficiency, rate of diffision of innovations, economies of scale and the average inherent quality of human and non-human factors of production. Moreover, Kendrick says, differences in

productivity levels in different regions may also be attributed to the socio-economic institutions and the basic values of the society /Kendrick, 19_7.

As against the great body of literature on total factor productivity which attribute most of the growth in total output to technical change, Griliches /_12, 13_7 says that if the inputs are adjusted for quality changes and correct weights are used for aggregating the inputs, the role of disembodied technical change would be drastically reduced. Identifying the sources of growth for the U.S. agriculture during the twenty year period 1940-60, Griliches /_12_7 attributes changes in output growth to changes in the quantities and qualities of inputs and to economies of scale. He says, of the observed productivity growth about one third may be attributed to improvements in the quality of inputs, about one fourth to the use of weights based on factor-income shares and the remaining to economics of scale.

Jorgenson and Griliches /_16_7 observe that if real product and real factor inputs are accurately measured the observed growth in total factor productivity is negligible. According to them most of the estimates of total factor productivity contain errors due to which the role of total factor productivity is overestimated[1].

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[1] Jorgenson and Griliches /_16_7 discuss errors of aggregation when investment and consumption goods and labor and capital services are combined; errors of measurement in the prices of investment goods because prices of inputs to the investment goods sector are used instead of the prices of the outputs of the investment goods sector; errors arising due to the assumption that the flow of labor and capital are proportional to the stocks of labor and capital; errors in aggregating labor services and capital services. Some other errors have been discussed by Griliches /_12_7.

Tang [35] has identified the sources of growth for the Chinese agriculture for the period 1952-65 and explain the 'raison d' entre for the celebrated Great Leap Forward'. His total factor productivity index is obtained by dividing the output index by the aggregate input index, which is a measure of technical change. Tang finds that the total factor productivity index has declined almost continuously during the period of the study. During the first five year plan period 1952-57 it declined by 6 to 7 percent. According to Tang the success or failure of an agricultural policy is to be judged not on the basis of its effect on agricultural output, but on whether or not the policy helped in the attainment of the long-term development objectives. In the Stalinist model which the Chinese had adopted the role of agriculture was to free industrialization from the agricultural constraint. It is on this basis that Tang pronounces the Chinese agricultural policy as a failure, since the restrictive influence of agriculture on industrialization not only continued but actually worsened. According to Tang the decline in productivity is to be attributed to the disincentive effect of the agricultural policies adopted by Peking. The Chinese adopted extractive and developmental policies which were mutually inconsistent with each other. Moreover, although the traditional factors of production were being used massively, the law of diminishing returns had set in by 1957. The situation was aggravated more because at a time when the traditional sources of growth were almost exhausted no steps were taken to modernize the agricultural sector. Infact, the intersectoral transformation was completely ignored and Peking tried to industrialize the rural sector cheaply by using resources produced from within this sector. The industrial sector was not to be burdened to produce agricultural machinery and materials needed to modernize the agricultural sector.

The present study draws a great deal of inspiration from Tang's study /35/ on the Chinese agriculture. There are no studies in the literature which have calculated a total factor productivity index for Pakistan's agriculture. Thus, this is a pioneering study. Its purpose is to identify the sources of growth of agricultural output in Pakistan during the period 1953-54 to 1977-78 and the sub-periods 1953-54 to 1966-67 and 1966-67 to 1977-78. Such a breakup helps to compare between the pre and the post Green Revolution periods. The sources of growth have been identified by doing growth accounting using the linear production function approach. A total factor productivity index has been obtained by dividing the value added index by the aggregate input index. The construction of such indexes presents some problems; but instead of getting involved with them in this paper, I shall simply follows Solow and not 'try to justify what follows by calling on fancy theorms on aggregation and index numbers. Either this kind of aggregate economics appeals or it doesnt' /Solow, 33/. If it appeals, quite interesting and meaningful results can be drawn from the study, although these will be rather crude in nature because of the highly aggregated nature of the study. The study is divided into four sections. Section I contains the conceptual frame-work, Section II briefly discusses the data problems. The input indexes, the value added index and the total factor productivity indexes are contained in Section III. Sources of growth of agricultural output have been identified in this section. The policy implications are presented in Section IV, while Section V contains the summary and the conclusion.

I. A Review of Concepts and Methodology

The effect of technological change is to bring about a shift of the production function, resulting in a greater volume of output with the same amounts of inputs as before or the production of the same amount of output with fewer inputs. Strictly speaking, the introduction of an existing technique which has not been used so far or some alteration in the existing techniques is not technological change, unless it results in shifting the production function. Technical progress is also not the same thing as diffusion of existing technical knowledge which does not change production possibilities or with scientific research which might not produce any new knowledge at all.

While a direct measurement of technical progress is not possible, the usual procedure is to measure technical change by its effects on the growth of national income or factor productivity. In order to gauge the effects of changes in technology productivity indexes are used. The index might be an arithmetic index obtained by dividing the output index by the input index, or a geometric index obtained from some multiplicative form of the production function. Earlier partial productivity indexes were used which measured the productivity of only one factor, mostly labor. But this approach has now been abandoned in favour of a total factor productivity approach, which is more suitable for a world where there are more than one factor of production. The rate of growth of total factor productivity is the difference or the residual between the rate of growth of real product and the rate of growth of real factor input. The rates of growth of real product and real factor inputs are the weighted averages of the rates of growth of products and factors of production. The weights are the relative shares of each product in total output and of each factor input in the total value of inputs.

Construction of a weighted arithmetically aggregated index of output, inputs and the total factor productivity index entail the following assumptions:

(1) the factor markets are competitive.

(2) the aggregated production function is strictly linear.

(3) technical progress represents neutral shifts in the production function.

Let the aggregate production function in agriculture be linearly homogeneous of the additive type

$$Y = \sum_{i=1}^{3} a_i X_i \tag{1}$$

or

$$Y = a_1 X_1 + a_2 X_2 + a_3 X_3 \tag{2}$$

Where Y is total output or value added conventionally aggregated, X_i stands for land, labor, and capital; and the coefficient a_i is the marginal product (in value), or price in competitive equilibrium of each of the three inputs.

Introducing time and assuming neutral shifts in the production function (1) becomes

$$Y_t = A(t) \sum_{i=}^{3} a_{it} X_{it} \tag{3}$$

Expressing (3) in index number form and recognizing that A for the base year is equal to one

$$\frac{Y_t}{Y_o} = A(t) \frac{\Sigma a_{it} X_{it}}{\Sigma a_{io} X_{io}} \tag{4}$$

or

$$Q_{ot} = A(t) I_{ot} \tag{5}$$

Where I_{ot} is the aggregate input index, also the expected output index in the absence of any shift of the production function. A (t) is seen as the total factor productivity index for year t with base in year o.

$$A(t) = \frac{Q_{ot}}{I_{ot}} \qquad (6)$$

A convenient variant of I_{ot} is as follows:

$$I_{ot} = \Sigma \frac{\frac{a_{io} X_{io}}{\Sigma a_{io} X_{io}}}{\frac{X_{it}}{X_{io}}}$$

Where,

$\frac{a_{io} X_{io}}{\Sigma a_{io} X_{io}}$ are the factor income share weights;

$\frac{X_{it}}{X_{io}}$ are the relative input quantities or the quantity index of each of the three inputs; and I_{ot} itself is the expected output index as stated earlier.

The effect of technological change is to bring about a change in one or more parameters of the production function. Technical change is defined as Hicks neutral if it changes the parameters of the production function without changing the marginal rates of substitution between them. Harrod defined technical change as neutral which with a constant rate of interest left the capital-output ratio unchanged, while Solow's definition measures the bias along a constant labor-output ratio. Non-neutral technical change brings about a change in the parameters of the production function also at the same time affecting the marginal rates of substitution.

A distinction has been made between embodied and disembodied technical change[1]. Embodied technical change is incorporated in the latest model of the input. According to the "Embodiment Hypothesis" improvements in technology affect output when these improvements are transmitted through changes in the quality of the inputs[2].

Disembodied technical progress has been identified with the shift of the production function, particularly with a shift in the efficiency parameter. Moreover, disembodied technical change is assumed to be neutral to scale. Since non-neutral movements of the production function and changes in the degrees of economies of scale imply the use of different techniques they are likely to arise with embodied technical change. Thus, embodiment gives rise to an interaction between movements along the production function and the shift of the function/J. Lingard and A. J. Rayner, 22_/.

[1]For a detailed discussion of the embodied and disembodied models of technical progress see C. Kennedy and A.P. Thirlwall /_21_/, J.Lingard and A.J. Rayner /_22_/ and Ishaq M. Nadiri /_26_/.

[2]There is considerable disagreement as to whether the improvements in technology are transmitted through the capital input or whether labor is also a vehicle through which technical change might be transmitted. The vintage models developed by L. Johnsen, Kaldor, Mirrlees and Solow establish a link between capital and technical change. According to these models new technology is incorporated in new capital equipment. Solow's capital vintage model assumes that capital equipment of the same vintage is identical and different from capital equipment of other vintages. And capital equipment of the latest vintage is more productive as compared with that of the preceding vintage/Nadiri, 26_/.

Arrow and Kaldor also use capital embodiment models of technical change where technical progress is exogenous and embodied in the latest capital equipment/Nadiri , 26_/. Technical progress may also be transmitted through the labor input, by changing the characteristics of the labor input e.g. improvement in the educational levels, acquisition of new skills etc. This type of approach is reflected in the works of Denison /_7_/ Griliches /_12, 13_/ and Kendrick /_19, 20_/.

II. Data Problems and Limitations of the Study

The sources of data have been the Agricultural Statistics of Pakistan, various issues; Production Yearbooks of the FAO, various issues; Survey Report on Farm Power, Machinery and Equipment in Pakistan, December 1967. The data have also been taken from some studies and these have been mentioned in the footnotes to Table I.

Data on land refers to cropped acres in Table I, to net area sown in Table III and to cultivated area in Table IV. Data on agricultural labor force refers to the economically active population in agriculture. Data on capital refers to the working cattle, buffaloes, horses, asses and camels and to private tubewells. Time series data on tractors was not available. Moreover, the capital series does not include data on farm implements, farmer's dwellings and other possessions, the capital series are, therefore, understated. However, the rate of growth is exaggerated. Value added by agriculture has been used rather than the output of the agricultural sector, since the output series contained in the 25 years of Pakistan when compared with the value added by agriculture were almost identical. Therefore, value added series were used and the intermediate inputs like seeds, fertilizers and pesticides were excluded from the input side also.

The study had to make compromises with whatever data was available. Any missing data was estimated by means of linear interpolation. The original plan was to compute a 'Divisia Index'[1], but this plan had to be abandoned due to the non-availability of data.

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[1] In a Divisia Index the weights used for aggregating the inputs are based on the average of the input prices for all the consecutive years.

III. *Results*

The methodology discussed in Section I was used to compute indexes for the inputs, value added and total factor productivity. These indexes are presented in Table II, the base year for the indexes is 1959-60=100. The index on capital is composite. It includes livestock and private tubewells. The livestock and tubewells series were aggregated by means of weights which were based on the relative cost of each of these inputs in total capital cost in 1966-67. These weights are 94.1 percent for livestock and 5.9 percent for tubewells[1]. The inputs, land, labor and capital were then aggregated into an aggregate input index by assigning the following weights: Land 29.4 percent, Labor 58.8 percent and Capital 11.8 percent[2]. The total factor productivity index was obtained by dividing the value added index by the aggregate input index[3].

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[1]In 1966-67 there were 51,327 private tubewells in the country. Breakup of these tubewells into diesel and electric was not available for 1966-67. So the average percentage share of diesel and electric tubewells for eight years 1970-71 to 1977-78 were used to divide the total private tubewells into electric and diesel in 1966-67. Total annual cost (fixed + variable cost) of an electric tubewell in 1966-67 was Rs. 3,433. This is the average of the total annual cost of an electric tubewell in the Gujranwala, Sialkot region and in the Multan, Sahiwal region/Leslie Nulty , 27_/. Total annual cost of a diesel tubewell in 1966-67 was Rs. 5,468.5. This is the average of the total annual cost of a diesel tubewell in the Gujranwala, Sialkot region and in the Multan, Sahiwal region/Leslie Nulty, 27_/. This is how the total annual cost of tubewells for 1966-67 was calculated. Cost on livestock was obtained by multiplying 7.9 million working livestock in 1966-67 by Rs. 500 i.e. cost of maintaining a working animal/Swadesh R. Bose and Edwin H. Clark , 4_/. The total cost on livestock and tubewells were added to get total cost on capital and the relative shares of livestock and tubewells were the weights.

[2]These weights have been derived from Tang /_36_/. The weights given are: Land 25 percent, Labor 50 percent, capital 10 percent and current inputs 15 percent. Since current inputs have not been included, the weights have been derived for land, labor and capital.

[3]A geometric index of technical change was also obtained by fitting a Cob-Douglas Production Function both of the restricted type and the one with variable returns to scale. These results have however, not been reported in this paper.

Table I

Agricultural Inputs in Pakistan 1953-54 to 1977-78

Years	Value Added by Agriculture (in million Rs.)	Land (Cropped acres in millions)	Agricultural Labor Force (in millions)	Livestock (in million heads)	Tubewells (in numbers)
1953-54	4532	32.77	6.28[e]	6.5	990
1954-55	4320	32.80	6.33[e]	6.1	1300
1955-56	4406	34.32	6.38	6.1	1600
1956-57	4502	35.00	6.77[e]	8.2	1900
1957-58	4578	34.42	7.16[e]	8.4	2200
1958-59	4822	35.41	7.55[e]	8.4	3300
1959-60	4775	36.29	7.93	6.8	4600
1960-61	4709	36.72	8.97	6.9	8000
1961-62	5127	37.69	9.28[e]	7.0	13000
1962-63	5486	38.21	9.59[e]	7.5	18400
1963-64	5638	37.40	9.89	7.0	25000
1964-65	6018	40.14	10.05[e]	7.5	31600
1965-66	5993	38.41	10.21	8.3	40207
1966-67	6421	40.54	10.35[e]	7.9	51327
1967-68	7434	41.86	10.49	7.6	62163
1968-69	7924	40.12	10.41[e]	7.3	72149
1969-70	8916	41.45	10.33	7.0	79223
1970-71	8463	41.07	10.73	6.6	89157
1971-72	8843	41.01	10.86	7.9	98755
1972-73	8951	41.82	10.98[e]	8.0	109541
1973-74	9429	45.15	11.10[e]	8.1	120506
1974-75	9134	42.90	11.22[e]	8.2	144271
1975-76	9672	44.51	11.34[e]	8.3	150117
1976-77	9864	44.98	11.46[e]	8.4	156910
1977-78	10076	45.45	11.58[e]	8.4	160901

Data on Value Added:

Data on value added by agriculture refers to the value added by agriculture at the constant factor cost of 1959-60. Only value added by major and minor crops has been taken. This series does not include value added by livestock, fishing and forestry. The data on value added is from the Pakistan Economic Survey 1979-80, Government of Pakistan.

Data for the land input is from the Agricultural Statistics of Pakistan, 1975 and 1978, Ministry of Food and Agriculture, Government of Pakistan.

Data for agricultural labor force is from the Production Yearbooks, various issues. FAO denotes our own estimates which have been arrived at by means of linear interpolation.

Table I contd. on p../12

Method of Estimation for Livestock:

For entire period 1953-54 to 1977-78 total livestock population was available. For the period 1971-72 till 1977-78 breakup of the livestock population into cattle, buffaloes, horses, asses and camels was also available. For cattle and buffaloes the statistics on working cattle and working buffaloes was also available. (but not for horses, camels and asses). From the Survey Report on Farm Power, Machinery and Equipment the percentage of draft camels, percentage of draft horses in total horses population and the percentage of draft assess in total asses was obtained. These percentages are as follows: Of the total camel population 56 percent are draft camels, of the total asses population 84 percent are draft asses and of the total horses 7 percent are draft horses. From the camels, horses and asses population draft camels, horses and asses were calculated and added to the draft cattle and buffaloes to get total draft animals for the period 1971-72 to 1977-78.

For the period 1953-54 to 1970-71.

For this period total livestock population was available (except for the years 1967-68 to 1970-71 which was estimated by means of linear interpolation) For the years 1971-72 till 1977-78 total livestock population as well as the draft livestock was available. Getting the percentage of draft livestock in total livestock for the years 1971-72 to 1977-78 the average percentage share of draft animals in total animals was obtained for these eight years, which worked out to be 8.5 percent. That means on an average of the total livestock population 8.5 percent are draft animals. So for the years 1953-54 to 1970-71 8.5 percent of the total livestock population was taken as draft animals. Data for livestock is from the Agricultural Statistics of Pakistan, 1978 and the Survey Report on Farm Power, Machinery and Equipment in Pakistan, December 1967.

Data for Tubewells:

Tubewells refers to private tubewells only.

From 1953-54 to 1964-65 the data is from Ghulam Mohammad [26]. From 1965-66 to 1969-70 the data refers to the West Pakistan University of Engineering and Technology estimates quoted by Jerry B. Eckert [8]. From 1970-71 to 1977-78 the data has been taken from the Agricultural Statistics of Pakistan 1978, which contained private tubewell numbers for all the provinces except Sind, for which breakup between private and public tubewells was not available. So for each year the percentage of private tubewells in total tubewells for Punjab, N.W.F.P. and Baluchistan were used to estimate the number of private tubewells in Sind.

Table II

Aggregate Input Index, Value Added Index and the Total Factor Productivity Index 1953-54 to 1977-78

1959-60 = 100

Years	Land Index	Labor Index	Capital Index	Aggregate Input Index	Value Added Index	Total Factor Productivity Index
1953-54	90.3	79.2	91.2	83.9	94.9	113.1
1954-55	90.4	79.4	86.1	83.7	94.2	112.5
1955-56	94.6	80.5	86.5	85.4	92.3	108.1
1956-57	96.4	85.4	115.9	92.2	94.3	102.3
1957-58	94.8	90.3	119.8	95.0	95.9	100.9
1958-59	97.6	95.2	120.4	98.9	101.0	102.1
1959-60	100.0	100.0	100.0	100.0	100.0	100.0
1960-61	101.2	113.1	105.8	108.7	98.6	90.7
1961-62	103.9	117.0	113.5	112.7	107.4	95.3
1962-63	105.3	120.9	127.4	117.1	114.9	98.2
1963-64	103.1	124.7	128.9	118.8	118.1	99.4
1964-65	110.6	126.7	144.3	124.0	126.0	101.6
1965-66	105.8	128.8	166.5	126.5	125.5	99.2
1966-67	111.7	130.5	175.2	130.2	134.5	103.3
1967-68	115.3	132.3	184.9	133.5	156.7	117.4
1968-69	110.6	131.3	193.6	132.6	165.9	125.1
1969-70	114.2	130.3	198.4	133.6	186.7	139.8
1970-71	113.2	135.3	205.7	137.1	177.2	129.2
1971-72	113.0	136.9	236.0	141.6	185.2	130.8
1972-73	115.2	138.5	251.2	144.9	187.5	129.4
1973-74	124.4	140.0	266.6	150.3	197.5	131.4
1974-75	118.2	141.5	298.5	153.2	191.3	124.9
1975-76	122.7	143.0	307.4	156.4	202.6	129.5
1976-77	123.9	144.5	317.5	158.8	206.6	130.1
1977-78	125.2	146.0	322.6	160.7	211.0	131.3

Note: This table has been computed from the data contained in Table 1.

Table II shows that the total factor productivity index has been declining almost continously from 1953-54 till 1961-62, after which it starts picking up slowly. However, it is not until 1966-67 that there is a sharp acceleration in the rate of productivity advance, which slows down during the 1970's. The average annual rate of growth of the value added index during 1953-54 to 1977-78 is 3.50 percent, while the aggregate input index grows at the rate of 2.77 percent per annum. The total factor productivity index increased at the average annual rate of 0.76 percent. The rate of growth of total inputs explain 79.05 percent of the growth in value added while 21.66 percent is due to technical change. In the terminology of production theory, movements along a given production function explains 79.05 percent of the observed increase in output, while the shift of the production function explain the remaining 21.66 percent.

During the sub-period 1953-54 to 1966-67 the rate of growth of the value added index was 2.42 percent, while that of the aggregate input index was 3.51 percent. During this period total factor productivity declined at the average rate of 1.01 percent per annum. During the latter period i.e. 1966-67 to 1977-78 the value added index grew at the average rate of 4.58 percent per annum, the aggregate input index at 2.02 percent, while total factor productivity increased at the rate of 2.53 percent per annum. The rate of growth of inputs explain 44.13 percent of the observed increase in output while 55.22 percent is due to technical change.

In Table II the total factor productivity index has been computed by using cropped area for the land input. In Table III another total factor productivity index has been computed using net area sown for the land input. Since cropped area increased as a result of innovations, some

Table III

Aggregate Input Index, Value Added Index and the Total Factor Productivity Index Using Net Area Sown 1953-54 to 1977-78

1959-60 = 100

Years	Land (Net Area Sown[1]) in millions	Land Index	Labour Index	Capital Index	Aggregate Input Index	Value Added Index	Total Factor Productivity Index
1953-54	29.94	92.7	7[illegible].2	91.2	84.6	94.9	112.2
1954-55	29.30	90.7	79.8	86.1	83.7	94.2	112.5
1955-56	30.44	94.1	80.5	86.5	85.2	92.3	108.3
1956-57	31.22	96.6	85.4	115.9	92.3	94.3	102.2
1957-58	31.01	96.0	90.3	119.0	95.4	95.9	100.5
1958-59	31.92	98.8	95.2	120.4	99.2	101.0	101.8
1959-60	32.31	100.0	100.0	100.0	100.0	100.0	100.0
1960-61	32.78	101.5	113.1	105.8	108.8	98.6	90.6
1961-62	33.70	104.3	117.0	113.5	112.8	107.4	95.2
1962-63	34.04	105.4	120.9	127.4	117.1	114.9	98.1
1963-64	33.14	102.6	124.7	128.9	118.7	118.1	99.5
1964-65	34.98	108.3	126.7	144.3	123.4	126.0	102.1
1965-66	34.42	106.5	128.8	166.5	126.7	125.5	99.1
1966-67	35.16	108.8	130.5	175.2	129.4	134.5	103.9
1967-68	36.76	113.8	132.3	184.9	133.1	156.7	117.7
1968-69	35.21	109.0	131.3	193.6	132.1	165.9	125.6
1969-70	35.92	111.2	130.3	198.4	132.7	186.7	140.7
1970-71	35.68	110.4	135.3	205.7	136.3	177.2	130.0
1971-72	35.42	109.6	136.9	236.0	140.6	185.2	131.7
1972-73	34.75	107.6	138.5	251.2	142.7	187.5	131.4
1973-74	37.52	116.1	140.0	266.6	147.9	197.5	133.5
1974-75	36.48	112.9	141.5	298.5	151.6	191.3	126.1
1975-76	37.20	115.1	143.0	307.4	154.2	202.6	131.4
1976-77	37.32	115.2	144.5	317.5	156.3	206.6	132.2
1977-78	37.45	115.9	146.0	322.6	158.0	211.0	133.5

[1] Net area sown has been taken from the Agricultural Statistics of Pakistan, 1975 and 1978.

of the increases in productivity attributable to technical change is being attributed to land. A comparison of the two Tables show that total factor productivity is a little higher when net area sown is used, as one would expect. The analysis shows that some of the effects of technological change which were attributed to land have been isolated by using net area sown.

The average annual rate of growth of the value added index is still 3.50 percent during 1953-54 to 1977-78, while the aggregate input index grows at the average rate of 2.66 percent per annum, and total factor productivity at 0.86 percent per annum. Inputs now explain 76.00 percent of the observed increase in output while 24.86 percent is due to technical change.

During the sub-period 1953-54 to 1966-67 the average annual rates of growth of the value added index and the aggregate input index are 2.42 and 3.46 percent respectively, while total factor productivity declined at the rate of 0.95 percent per annum. During the latter period 1966-67 to 1977-78 the average annual rate of growth of the value added index was 4.58 percent, the aggregate input index increased at the average annual rate of 1.86 percent, while the average annual rate of growth of the total factor productivity index was 2.68 percent. Total inputs now explain 40.61 percent of the observed increase in output while 58.51 percent is due to technical change.

Since computation of total factor productivity is underestimated when cropped area is used for the land input and over-estimated when net area sown is used, another set of indexes of the aggregate inputs and total factor productivity have been computed where the land input refers to

Table IV

Aggregate Input Index, Value Added Index and the Total Factor Productivity Index Using Cultivated Area 1953-54 to 1977-78

1959-60 = 100

Years	Land (cultivated area) in milns.	Land Index	Labor Index	Capital Index	Aggregate Input Index	Value-Added Index	Total Factor Productivity Index
1953-54	38.39	94.1	79.2	91.2	85.0	94.9	111.6
1954-55	37.86	92.8	79.8	86.1	84.4	94.2	111.6
1955-56	38.70	94.9	80.5	86.5	85.4	92.3	108.1
1956-57	39.56	97.0	85.4	115.9	92.4	94.3	102.1
1957-58	40.14	98.4	90.3	119.0	96.1	95.9	99.8
1958-59	40.04	98.1	95.2	120.4	99.0	101.0	102.0
1959-60	40.80	100.0	100.0	100.0	100.0	100.0	100.0
1960-61	44.76	109.7	113.1	105.8	111.2	98.6	88.6
1961-62	44.23	108.4	117.0	113.5	114.1	107.4	94.2
1962-63	44.55	109.2	120.9	127.4	118.2	114.9	97.2
1963-64	45.30	111.0	124.7	128.9	121.2	118.1	97.4
1964-65	46.26	113.3	126.7	144.3	124.8	126.0	101.0
1965-66	47.54	116.5	128.8	166.5	129.6	125.5	96.8
1966-67	47.60	116.7	130.5	175.2	131.7	134.5	102.1
1967-68	48.00	117.7	132.3	184.9	134.2	156.7	116.8
1968-69	47.67	116.8	131.3	193.6	134.4	165.9	123.4
1969-70	47.53	116.5	130.3	198.4	134.3	186.7	139.0
1970-71	47.47	116.4	135.3	205.7	138.0	177.2	128.4
1971-72	47.16	115.6	136.9	236.9	142.3	185.2	130.1
1972-73	47.23	115.8	138.5	251.2	145.1	187.5	129.2
1973-74	47.87	117.3	140.0	266.6	148.3	197.5	133.3
1974-75	48.29	118.4	141.5	298.5	153.2	191.3	124.9
1975-76	48.98	120.1	143.0	307.4	155.7	202.6	130.1
1976-77	48.81	119.6	144.5	317.5	157.6	202.6	128.6
1977-78	49.28	120.8	146.0	322.6	159.4	211.0	132.4

Data for cultivated area has been taken from the Agricultural Statistics of Pakistan 1975 and 1978.

cultivated area. These indexes are presented in Table IV. A comparison of Table II with Table IV shows that total factor productivity is not under-estimated when cropped area is used for the land input. A similar comparison of Tables III and IV shows that total factor productivity is a little over-estimated when net area sown is used.

The analysis shows that there was virtual stagnation in the agricultural sector during the 1950's which was due, mainly, to the use of age old technology, constraint on vital inputs such as water, the existence of several bureaucratic controls on agriculture and the dis-incentive effect of government price policies[1]. The prices of food grains such as rice and wheat were very low during this period due to which there was a decline in their marketable surplus. Moreover, the bureaucratic controls on agriculture introduced by the British government during the 1940's as war time measures continued during the 1950's. These included restrictive zoning of surplus areas and the compulsory sale of surplus food grains to the government at prices which were less than the market prices.

The dramatic accelration in agricultural production during the period 1966-67 - 1977-78 when agricultural value added grew at the rate of 4.5 percent per annum as compared with only 2.4 percent during the period 1953-54 - 1966-67 may be explained by by the greater availability of new and improved inputs like water, fertilizers, and the high yielding seed varieties. Public policy played an increasing important role[2] by

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[1]For a detailed discussion of the bureaucratic controls on agriculture and the price policies pursed by the governments during the 1950's see Burki [5].

[2]See Burki [5] and Falcon and Gotsch [9].

granting generous subsidies on the use of these inputs. Some other measures that helped to modernize the agricultural sector during this period were import of tubewell parts at favourable terms of exchange and provision of electricity at a low cost for the tubewells. The support prices of major agricultural crops helped to turn the terms of trade in favour of the agricultural sector. In April 1960 direct controls on wheat movement and wheat prices were abolished. The government fixed the minimum price of wheat at Rs. 13.50 per maund and sales to the government were now voluntary.

It is said that the agricultural revolution in Pakistan began with water in the early sixties and was followed by the Green Revolution in the late sixties. During this period the world's largest earth-filled dams, the Mangla and the Tarbela came into operation with the purpose of surface storage and regulation of seasonal river flows. Additional supplies of water from these dams helped to increase the acreage under the wheat crop. Between 1960 and 1969-70 the irrigation water increased from 57.2 MAF (million acre feet) to 80.1 MAF, reflecting an increase of almost 50 percent Leslie Nulty [27]. By 1972-73 the total availability of irrigation water had increased to 95.7 MAF Annual Plan [3]. More important, however, were the installation of tubewells, particularly private tubewells on a massive scale during this period. Increase in irrigation water due to the installation of tubewells, not only led to a more intensive use of the traditional factors of production, but also helped in the introduction and diffusion of other technical innovations. It was, infact, a single technical change giving rise to a chain of technical innovations. The output augmenting effects of tubewell water

were not just the increases in output directly attributable to increased supply of irrigation water, but more important was the increase in output due to increased use of the traditional factor inputs, as well as the modern inputs, and the increased efficiency with which these inputs were used.

According to Ghulam Mohammad [24] the additional water made available due to the installation of tubewells led to increased cropping intensity by increasing the area sown more than once and reducing fallow (~~Annexure I~~) Ghulam Mohammad [24] and Kaneda and Ghaffar [18] observed increase in acreage of crops that were irrigated by tubewell water. Marked increases in acreage under cotton, rice, sugarcane and wheat were observed. Installation of tubewells was also followed by increase in the size of farming unit. The average size of the farm increased by 11 percent. This was possible by bringing unused land under cultivation, renting of land from non-tubewell farmers and the increased income accruing to the farmers with the installation of tubewells was spent on purchasing land Kaneda and Ghaffar [18].

Ghulam Muhammad [24], Kaneda and Ghaffar [18] and Leslie Nulty [27] observe that the increased supply of irrigation water leads to increased use of both the traditional inputs like land, labor and livestock (Annexure II) as well as the non-traditional inputs like chemical fertilizers. Increased supply of irrigation water not only leads to increased use of traditional and modern inputs but also increases the efficiency with which these inputs are used.

Ghulam Muhammad [24] and Kaneda and Ghaffar [18] have shown that the yield of crops for tubewell farmers is higher as compared with

the non-tubewell farmers (see Annexure III) Installation of tubewells also led to better methods of cultivation due to which the yield increased. Drills for line-sowing, improved cultivators, inter-culture implements and mouldboard ploughs were first used by the tubewell farmers, and were later on taken over by the non-tubewell farmers.

During the period 1959-60 to 1964-65 the increase in the supply of irrigation water due to increase in the number of private tubewells from 4,600 to 31,600, helped in the expansion of crops which grew at the rate of 4.8 percent per annum during this period (Table II) Agricultural productivity, however, remained stagnant during this period. Agricultural productivity started rising from 1966-67 when increased supply of water was combined with other modern inputs like high yielding seeds and fertilizers. It is due to the 'multifactor interaction' or what Falcon and Gotsch /9/ call the 'interaction effect' that agricultural productivity started rising. They maintain that increases in output not related to the use of modern inputs are to be explained by the more than additive effects of using several inputs in combination and better production techniques. Refering to experimental studies which show increase in consumption of fertilizer due to increase in water supply and to Ghulam Muhammad's study /24/ Falcon and Gotsch observe that the interaction effect of using water and fertilizer simultaneously may have been substantial. Identifying the sources of growth for Pakistan's agriculture during the period 1960-65 Falcon and Gotsch maintain that of the observed growth of major crops of nearly 5 percent per annum, more than half is attributed to increased supply of irrigation water, almost one third to the use of inputs like seeds, fertilizers and insecticides and about one sixth to better farming practices and increase in labour productivity /Falcon and Gotsch, 9/.

The foregoing analysis shows that the trend rate of growth of crops during the latter half of the 1960's was not just a weather phenomenon, but a structural transformation involving an upward shift of the production function stemming from investment in inputs such as water, seeds and fertilizers. The analysis, however, shows that there has been a deceleration in in the rate of productivity advance during the 1970's. And if this trend is to continue, it will not be for quite sometime till there is another shift of the production function. During the late 1960's the water-seed-fertilizer package proved to be necessary as well as sufficient for increasing agricultural output and productivity, in an environment beset with several barriers to growth like a high proportion of tenancy, skewed distribution of land ownership, conservative environment of the rural society, lack of education etc. This may be thought of as similar to Solon Barraclough's [11] 'Modernization Strategy' which assumes that rural development can be achieved by introducing modern techniques of production without reforming the social structure simultaneously. Technical change is introduced in an environment beset with the institutional barriers to growth, although it is acknowledged that at some future date these obstacles will have to be dealth with. It appears that the strength of the institutional obstacles to development is now being felt in the rural environment of Pakistan, and the techniques of production by themselves, no doubt necessary, will no longer be sufficient to bring about an upward shift of the production function.

IV. Policy Recommendations

"Progress" has been defined as a process in which one set of problems is exchanged for another. Gotsch [10] says this is a very apt

description of what is happening in the developing countries. It is in-fact, also a very apt description of what has been happening on the agricultural scene in Pakistan. The history of agricultural development can roughly be divided into three phases. The phase from 1953-54 to 1966-67 when the constraining factor was inadequate supply of irrigation water. Removal of this constraint helped to increase agricultural output, but agricultural productivity remained stagnant during this period. Agricultural productivity started rising during the second phase 1966-67 to 1969-70 when increased supply of irrigation water was combined with other modern inputs like seeds and fertilizers. The rate of growth of agricultural productivity started decelerating during the third phase 1970-71 to 1977-78 inspite of the fact that modern technology continued to be used. The constraining factors during this period are the institutional obstacles to development like skewed distribution of land ownership, a high proportion of tenancy, conservative social environment of the rural areas, besides lack of education, health and extension facilities.

It has been observed that the encouragement given to the agricultural sector in the form of input subsidies, increase in the support prices of major crops, provision of electricity at a low cost, import of agricultural machinery and parts at favourable terms of exchange were instrumental in the adoption and diffusion of modern technology. Continuation of these incentives will help to keep the rate of return on modern technology high. However, the major focus of attention should now be on breaking the barriers which are responsible for the slow growth of agricultural productivity in recent years. A Land Reform Policy which aims at improving the distribution of land ownership, giving proprietorship rights to the tenants and consolidating fragmented holdings will help in the diffusion of the "miracle"

inputs. Since according to several empirical studies the rate of adoption of modern technology is much less on farms which are not cultivated by the owners. Fragmentation of holdings is another factor which inhibits the use of modern methods. If further increases in agricultural productivity are to be realized, a thorough going reform aimed at improving the social environment of the rural areas will have to be undertaken. It should be of interest for policy makers to note how the electrification of the villages undertaken for the purposes of lighting the villages led to the spectacular adoption of the tubewell technology, and how this technology acted as a catalyst in introducing the biological and chemical invovations of the Green Revolution. The electrification of the villages should continue to receive the top priority that it deserves. Moreover, steps should be taken to provide health, education and extension facilities which are almost non-existent in the villages. This will help to improve the health of the rural population, make them more enlightened which will have very desirable consequences on agricultural productivity as well as the overall environment. According to a number of studies the rates of return accruing to agricultural modernization when these basic facilities have been provided are very high. For example Tang [37] finds internal rates of return as high as 30-35 percent per year due to basic rural education, agricultural research, development and extension facilities for the Japanese agriculture. Yhi-min Ho's study for the Taiwanese agriculture produces similarly interesting results. Griliches [14] has also accorded very high rate of return due to investment on account of basic education, research and extension for the U.S. agriculture. Schultz's innumerable works, to mention only [31] bring out very clearly the importance of investment in human capital.

V. Summary and the Conclusion

In this study we have computed total factor productivity for Pakistan's agriculture for the 25 years from 1953-54 to 1977-78 and have tried to identify the sources of growth of agricultural output. During this period the rate of growth of agricultural value added was 3.50 percent, while the aggregate input index grew at the rate of 2.66 percent per year (2.77 percent using cropped area for the land input) and total factor productivity at the rate of 0.86 percent (0.76 percent using cropped area). The rate of growth of inputs explain 76 percent (79 percent using cropped area) of the observed increase in output while 24.86 percent (21.66 percent using cropped area) is due to technical change. During the sub-period 1953-54 to 1966-67 the average annual rate of growth of the value added index was 2.42 percent while total inputs grew at the average annual rate of 3.46 percent (3.51 percent using cropped area) while total factor productivity declined at the rate of 0.95 percent per annum (1.01 percent when cropped area is used). Some of the factors responsible for the decline in total factor productivity during this period were the bureaucratic controls on agriculture, reliance on traditional technology, constraints on account of vital inputs such as water and the disincentive effect of government price policies. This was followed by the period of the great recovery 1966-67 to 1977-78 when agricultural value added grew at the rate of 4.58 percent while the aggregate input index at 1.86 percent per annum (2.02 percent using cropped area). Total factor productivity grew at the average annual rate of 2.68 percent (2.53 percent using cropped area). In the terminology of production theory movements along the production function explain 40.61 percent (44.13 percent using cropped area) of the observed increase in output while the shift of the function explains the remaining 58.51 percent (55.22 percent using cropped area). The analysis shows that

agricultural value added had started increasing as early as 1959-60 with the increase in the supply of irrigation water on account of the installation of tubewells, but agricultural productivity started rising only from 1966-67 when increased supply of irrigation water was combined with high yielding seeds and fertilizers. It was due to the 'interaction effect' between water, seeds and fertilizers that agricultural productivity rose at a spectacular rate during the period 1966-67 to 1969-70. During this period, the agricultural sector got a great deal of encouragement from the government in the form of liberal import of agricultural machinery and spare parts at favourable exchange rates, input subsidies, higher and stable prices for agricultural products etc. During the period 1970-71 to 1977-78 there was deceleration in the rate of productivity advance, and this has been attributed to the institutional obstacles to development in the form of skewed distribution of land ownership, high proportion of tenancy, a conservative social structure, lack of education, health and extension facilities etc. The paper ends with a pessimistic prognosis about the future. The present rate of growth of agricultural productivity shows that it will not be for quite sometime till there is another shift of the production function. The paper recommends that if the agricultural sector is expected to grew at the rate recorded during the late 1960's it should continue to receive encouragement from the government. The paper recommends that the major focus of attention should now be on breaking the barriers to growth. Pakistan has entered a stage where mere emphasis on the technique of production will not solve the problem. The emphasis should now be on providing extension facilities and on investment in human capital in the form of education and health facilities. A thorough going Land Reform which improves the distribution of land ownership and increases the number of owner-operators has also been recommended.

Annexure I

Cropping Patterns and Cropping Intensities[a] of Tubewell and Nontubewell Farmers, 1967[b]

Crops	Cotton Area		Rice Area		Both Area	
	Tube-well farmers	Nontube-well farmers	Tube-well farmers	Nintube-well farmers	Tube-well farmers	Nontube-well farmers
	(.....percent.....)					
Kharif Crops						
Cotton	31.6	19.8	1.8	4.9	19.7	13.9
Rice	4.4	0.5	41.0	17.5	19.1	7.3
Maize	1.3	1.5	0.5	1.0	1.0	1.3
Fruits	4.4	1.3	2.0	0.6	3.4	1.0
Kharif Fodders	14.1	11.9	16.0	13.5	14.9	12.5
Sugarcane	6.0	3.1	7.6	4.8	6.6	3.8
Other Kharif crops	0.5	0.0	0.0	0.0	0.0	0.0
Subtotal kharif	62.3	38.2	68.9	42.3	65.1	39.8
Rabi Crops						
Wheat	39.1	27.1	42.9	45.5	40.6	34.4
Oil seeds	1.0	1.0	3.5	1.6	2.0	1.2
Rabi pulses	1.0	1.3	0.1	0.6	0.6	1.0
Potatoes	0.6	0.1	5.9	2.0	2.8	0.9
Fodders	10.9	8.7	13.5	10.7	11.9	9.5
Other rabi crops	1.3	0.0	2.9	0.0	2.0	0.0
Subtotal rabi	53.9	38.3	68.8	60.4	59.9	47.0
Sugarcane	6.0	3.1	7.6	4.8	6.6	3.8
Fruits	4.4	1.3	2.0	0.6	3.4	1.0
Subtotal	10.4	4.4	9.6	5.4	10.0	4.8
Grand Total (Cropping intensity)	126.6	80.9	147.3	108.1	135.0	90.0

Source: ~~Ghulam Mohammad / 24 /~~. [18]

[a]Cropping intensity is defined as the ratio between the area cropped and the area cultivated.

[b]1967 denotes rabi (winter) crop of 1966-67 and kharif (summer) crop of 1967.

Annexure II

Land and Labor Inputs, Tubewell and Nontubewell Farms

	Nohtubewell Farms	Tubewell Farms
Average farm size	30.25 acres	33.60 acres
Average working hours per day:		
Family Labor	8.30 hours	10.44 hours
Hired Labor	9.20 hours	11.23 hours
Average	8.75 hours	10.84 hours
Labour per acre at average working hours:		
Family Labor	0.082 men	0.084 men
Hired Labor	0.045 men	0.061 men
Total Labor	0.127 men	0.145 men

Source: ~~Ghulam Mohammad / 24 /~~. [15]

Annexure III

Average Yield of Crops, Tubewell Farmers, and Nontubewell Farmers, 1967

	Average Yield		
	Rice Area	Cotton Area	Both Areas
	(.....maunds per acre.....)		
Tubewell farmers			
Cotton	5.6	10.6	10.4
Rice	22.8	28.7	23.0
Maize	15.4	15.3	15.3
Sugarcane	26.9	35.9	30.8
Wheat	13.1	16.9	15.3
Nontubewell farmers			
Cotton	7.9	8.8	8.7
Rice	22.2	20.2	22.7
Maize	12.3	12.4	12.4
Sugarcane	34.9	27.4	31.6
Wheat	12.4	15.0	13.6

Source: ~~Ghulam Mohammad / 24 /~~. [18]

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