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Technological Change in Pakistan's Agriculture: 1953-54 to 1978-79

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In this paper, total factor productivity has been computed and sources of growth identified for Pakistan's agriculture for the period from 1953-54 to 1978-79. Total factor productivity has been computed by doing growth accounting using the linear production function approach. The analysis shows that during the subperiod from 1964-65 to 1969-70, when the agricultural sector grew at a spectacular rate, more than 84 percent of the increase in output could be attributed to technological change and about 16 percent to increased use of inputs.

I. INTRODUCTION

The effect of technological change is to increase the output of any gi combination of inputs and is diagrammatically reflected in an outward shift of production function. While a direct measurement of technological change is possible, the usual procedure is to measure it in terms of its effects on the growth national income and/or factor productivity. This is customarily done with the use productivity indexes. The index might be an arithmetic index, obtained by divid the output index by the input index, or a geometric index. The rate of growth total factor productivity is the difference between the rates of growth of product a the factor inputs. The relative rates of growth in real terms of agricultural prod and the factor inputs are measured in terms of the weighted averages of the rate growth of products and factors of production – the weights being the relative sha of each product in total agricultural output and of each factor input in the to value of agricultural inputs.

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The purpose of this study is to compute total factor productivity for Pakistan's agriculture for the period 1953-1954 to 1978-1979.[1] The likely sources of agricultural growth and the factors responsible for agricultural stagnation during the different subperiods have also been identified with the help of the empirical evidence presented in other studies. Total factor productivity for Pakistan's agriculture has been estimated in this study by employing the growth-accounting technique which has been used elsewhere with success.[2] A total factor productivity index has been computed by dividing the index of agricultural value added by aggregate agricultural input index. Since total factor productivity has never been measured before for Pakistan's agriculture, the results of this study may be of interest to economists in general and to Pakistan policy-makers in particular.

The computation of indexes presents some problems, but instead of getting involved with them in this paper, we have followed Solow in not trying "to justify what follows by calling on fancy theorems on aggregation and index numbers. Either this kind of aggregate economics appeals or it doesn't" [22]. If it appeals, quite interesting and meaningful results can be drawn from the study, although these will be rather crude because of the highly aggregated nature of the study.

The study is divided into seven sections. Following Introduction, Section II discusses the conceptual framework while Section III discusses the estimation and adjustment of data. The agricultural input index, the agricultural value added index and the total factor productivity index are contained in Section IV, which also identifies the likely sources of growth of agricultural output as well as the factors responsible for agricultural decline during different phases. Section V discusses some of the limitations of the study, while the policy implications are presented in Section VI. Summary and conclusions are given in Section VII.

[1] The role of total factor productivity as a factor contributing to economic growth has become quite controversial in the literature. Abramovitz [1], Kendrick [12; 13] and Solow [22] attach great importance to total factor productivity as a factor contributing to growth. Kendrick's total factor productivity index for the U.S. agriculture during 1929–1966 increased from 52.6 to 126.6 [12]. And this he attributes to research and development, education, training and medical care as well as to changes in economic efficiency, rate of diffusion of innovations, economies of scale and the quality of human and non-human factors of production. On the other hand, Jorgenson and Griliches [10] observe that the unexplained residual which is labelled as technical change may be due to measurement errors, changes in the quality of the inputs, economies of scale, etc. Much of this controversy is due to the fact that while Abramovitz, Kendrick and Solow include only the conventional inputs, with the result that the contribution of the unconventional inputs is reflected in a large residual, Jorgenson and Griliches include non-conventional inputs like education, research and extension as separate variables, thus reducing the size of the residual.

[2] Work on total factor productivity started with the pioneering works of Abramovitz [1], Kendrick [12; 13] and Solow [22], followed by those of Denison [4] and Griliches [8, 9]. For the Chinese agriculture, total factor productivity has been computed and sources of growth identified by Tang [23].

II. THE MODEL

The construction of an arithmetically weighted aggregate index of inputs, output and total factor productivity entails the assumptions that the factor markets are competitive, the aggregate production function is strictly linear and technical progress is Hicks-neutral.

Let the aggregate production function in agriculture be linear and homogeneous:

$$Y = \sum_{i=1}^{n} a_i x_i \quad \ldots \quad \ldots \quad (1)$$

where Y is total output or value added, x_i stands for inputs like land, labour and capital, and the coefficient a_i is the marginal value product of each of the three inputs which in competitive equilibrium is equal to the market price of inputs. Thus equation (1) can be rewritten as

$$Y = \sum_{i=1}^{n} p_i x_i \quad \ldots \quad \ldots \quad (1')$$

where p_i is the price of the ith input.

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

$$Y_t = A(t) \sum_{i=1}^{n} a_{io} x_{it} \quad \ldots \quad (2)$$

Expressing equation (2) in index number form and holding A equal to one for the base year

$$\frac{Y_t}{Y_o} = A(t) \frac{\Sigma(a_{io} x_{it})}{\Sigma(a_{io} x_{io})} \quad \ldots \quad (3)$$

Substituting Q_t for Y_t/Y_o and I_t for $\frac{\Sigma(a_{io} x_{it})}{\Sigma(a_{io} x_{io})}$ we can rewrite equation (3) as

$$Q_t = A(t) I_t \quad \ldots \quad \ldots \quad (4)$$

where I_t is the aggregate input index, which is also the expected output index in the absence of technological change, and A(t) is the index of total factor productivity caused by neutral technological change for the year t. This reflects the key assumption of the study that the only factor responsible for an outward shift of the production function is technological change.

$$A(t) = \frac{Q_t}{I_t} \quad \ldots \quad \ldots \quad (5)$$

In terms of its components, I_t is

$$I_t = \sum_{i=1}^{n} \left[\frac{a_{io}\ x_{io}}{\Sigma a_{io}\ x_{io}} \frac{x_{it}}{x_{io}} \right] \quad \ldots\ldots\ldots \quad (6)$$

where $\frac{a_{io}\ x_{io}}{\Sigma a_{io}\ x_{io}}$ represents the factor income share weights; $\frac{x_{it}}{x_{io}}$ stands for the relative input quantities or the quantity index of each of the three inputs; and I_t itself is the expected output index, as stated earlier.

III. DATA ESTIMATION AND ADJUSTMENT

Data on Pakistan's agricultural value added have been given in Table 1 where they refer to the value added by major and minor crops at the constant factor cost of 1959-1960. The series does not include value added by livestock, fishing and forestry. The data on land refer to cultivated area, while those on agricultural labour force relate to the economically active population in agriculture. The data on agricultural capital stock refer to the draught animals, public and private tubewells, and tractors. The time series on capital does not include data on farm implements, farm dwellings and other possessions. It is difficult to say what the rate of growth implicit in the time series on capital would be if the capital inputs which are left out were also included. It should, however, be clear that if the excluded capital inputs have been growing at a rate faster than those of the draught animals, tubewells and tractors, then the rate of growth implicit in the capital series is underestimated. On the other hand, if the rate of growth of the missing capital inputs has been less than that of the included capital inputs, then the rate of growth may have been somewhat exaggerated.

There is no ready and regular source of data reporting the draught animal population on yearly basis in Pakistan. The calculation of the draught animals involved two modifications. While the numbers of draught cattle and buffaloes were available from 1971-1972 to 1978-1979 in [20], the same were not available for camels, horses and donkeys. Consequently, the numbers of draught camels, horses and donkeys were calculated from their total numbers using the respective proportions of draught animals to total number of each category given in [18]. The numbers thus obtained were added to the number of draught cattle and buffaloes in order to arrive at the total number of draught animals. Likewise, while the total livestock population for the period 1953-1954 to 1970-1971 was available, the number of draught animals was not available. The total number of draught animals was taken to be 8.5 percent of total livestock population as reflected by data for the period 1971-1972 to 1978-1979.

Table 1

Agricultural Inputs in Pakistan (1953-54 to 1978-79)

Years	Agricultural Value Added (Million Rupees)	Land (Cultivated Area in Million Acres)	Agricultural Labour Force (Millions)	Draughts Animals (Millions)	Private Tubewells (Numbers)	Public Tubewells (Numbers)	Tractors (Numbers)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1953-54	4532	38.39	6.28[e]	6.5	990	–	–
1954-55	4320	37.86	6.33[e]	6.1	1300	–	437
1955-56	4406	38.70	6.38	6.1	1600	–	546
1956-57	4502	39.56	6.77[e]	6.3[e]	1900	–	804
1957-58	4578	40.14	7.16[e]	6.5[e]	2200	–	1241
1958-59	4822	40.04	7.55[e]	6.7[e]	3300	–	1598
1959-60	4775	40.80	7.93	6.8	4600	256	3642
1960-61	4709	44.76	8.97	6.9	8000	1264	4192
1961-62	5127	44.23	9.28[e]	7.0	13000	1482	6495
1962-63	5486	44.55	9.59[e]	7.5	18400	2052	8943
1963-64	5638	45.30	9.89	7.0	25000	2206	11180
1964-65	6018	46.26	10.05[e]	7.5	31600	2206	12593
1965-66	5993	47.54	10.21	7.7[e]	40207	2344	13990
1966-67	6421	47.60	10.35[e]	7.9	51327	2626	17753
1967-68	7484	48.00	10.49	7.6	62163	3708	18991
1968-69	7924	47.67	10.41[e]	7.3	72149	5216	22420
1969-70	8916	47.63	10.33	7.0	79223	6266	26485
1970-71	8463	47.47	10.73	7.9[e]	89157	6527	28535
1971-72	8843	47.16	10.86	7.9	98755	6657	30277
1972-73	8951	47.23	10.98[e]	8.0	109541	7384	29879
1973-74	9429	47.87	11.10[e]	8.1	120506	7572	33173
1974-75	9134	48.29	11.22[e]	8.2	144271	8097	37877
1975-76	9672	48.98	11.34[e]	8.3	150117	8495	46032
1976-77	9864	48.81	11.46[e]	8.4	156910	10120	58047
1977-78	10076	49.28	11.58[e]	8.4	160901	11686	65759
1978-79	10545	49.79	11.70[e]	8.5	166948	11535	76269

Sources: For Column 2: [19].
For Columns 3 and 5: [20].
For Column 4: [7].
For Column 6: [5, 14 and 20].
For Column 7: Unpublished data made available by Pakistan's Water and Power Development Authority (WAPDA).
For Column 8: [17].

Note: Figures marked with superscript e are our own estimates arrived at by means of linear interpolation.

Data on private tubewells for all the provinces were available from [5, 14 and 20]. For Sind the break-up between private and public tubewells was not available. The percentages of private tubewells in total tubewells for the Punjab, the NWFP and Baluchistan were used to estimate the number of private tubewells in Sind for each year.

The data on tractors are based on the import data which were available from 1959-1960 onwards. However, on the basis of the rate of growth of the index of agricultural machinery, the data on tractors in 1959-1960 were divided for the 1954-1955 to 1959-1960 period on an annual basis and added together to get cumulative tractor numbers. From 1954-1955 to 1961-1962 the data refer to gross number of tractors, net of depreciation. (The tractors depreciate in about 8–10 years.) From 1962-1963 till 1978-1979 the depreciation of tractors has been accounted for by assuming that one-third of the tractors depreciate after eight years, one-third after nine years and one-third after ten years.

IV. RESULTS

The methodology discussed in Section II was used to compute indexes for the inputs, value added and total factor productivity.[3] These indexes are presented in Table 2 and shown in Fig. 1. The base year for the indexes is 1959-1960. The inputs have been aggregated and converted into index numbers by taking into account yearly changing (not constant) weights based on the prices of those inputs in 1966-1967. The computation of these indexes has been discussed in detail in Appendix I. In the following paragraphs we discuss the movements of the three indices relating to value added, aggregate inputs and total factor productivity and their economic significance during the 1953-1954 to 1978-1979 period and subperiods.

Changes in Total Factor Productivity: 1953-1954 to 1978-1979

We have tried to isolate variations in output on account of both the movement along the production function and the shift of the function. Movements in the total factor productivity index have been identified with the shift of the function or with technological change, whereas changes in the aggregate input index have been identified with movements along the production function or with increase in output attributable to increased use of the inputs.

[3]Total factor productivity was first computed by using cropped area for the land input. But since cropped area increases as a result of innovations some of the increases in productivity attributable to technical change may have been attributed to land. Therefore, another set of indexes was computed using net area sown for the land input. In order to ensure that the estimates of total factor productivity, obtained when net area sown is used, are not overestimated, another set of indexes was computed where the land input refers to cultivated area and these are presented in Table 2. Since the different estimates of total factor productivity do not differ very much from one another, the other two sets of indexes have not been reported in order to avoid repetition.

Table 2

Input Indexes, Value Added Index and the Total Factor Productivity Index

Years	Land Index	Labour Index	Capital Index	Aggregate Input Index	Value Added Index	Total Factor Productivity Index
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1953-54	94.1	79.2	92.4	86.8	94.9	109.3
1954-55	92.8	79.8	87.0	85.7	94.2	109.9
1955-56	94.9	80.5	87.2	86.8	92.3	106.3
1956-57	97.0	85.4	90.3	90.4	94.3	104.3
1957-58	98.4	90.3	93.4	93.7	95.9	102.3
1958-59	98.1	95.2	96.8	96.5	101.0	104.7
1959-60	100.0	100.0	100.0	100.0	100.0	100.0
1960-61	109.7	113.1	104.2	110.3	98.6	89.4
1961-62	108.4	117.0	108.8	112.5	107.4	95.5
1962-63	109.2	120.9	119.7	116.5	114.9	98.6
1963-64	111.1	124.7	116.4	116.6	118.1	101.3
1964-65	113.4	126.7	126.6	121.0	126.0	104.1
1965-66	116.5	128.8	133.5	124.2	125.5	101.0
1966-67	116.6	130.5	142.6	126.8	134.5	106.1
1967-68	117.7	132.3	144.3	128.3	156.7	122.1
1968-69	116.8	131.3	147.2	129.3	165.9	128.3
1969-70	116.8	130.3	148.8	129.1	186.7	144.6
1970-71	116.4	135.3	160.9	130.6	177.2	135.7
1971-72	115.6	136.9	171.4	135.2	185.2	137.0
1972-73	115.8	138.5	177.2	137.0	187.5	136.9
1973-74	117.3	140.0	184.5	139.6	197.5	141.5
1974-75	118.4	141.5	197.8	142.9	191.3	133.9
1975-76	120.1	143.0	205.7	145.6	202.6	139.1
1976-77	119.6	144.0	217.4	148.1	206.6	139.5
1977-78	120.8	146.0	224.4	150.5	211.0	140.2
1978-79	121.8	147.5	231.3	152.8	220.8	144.5

Note: This table has been computed from the data contained in Table 1. The method of computation has been discussed in detail in Appendix I.

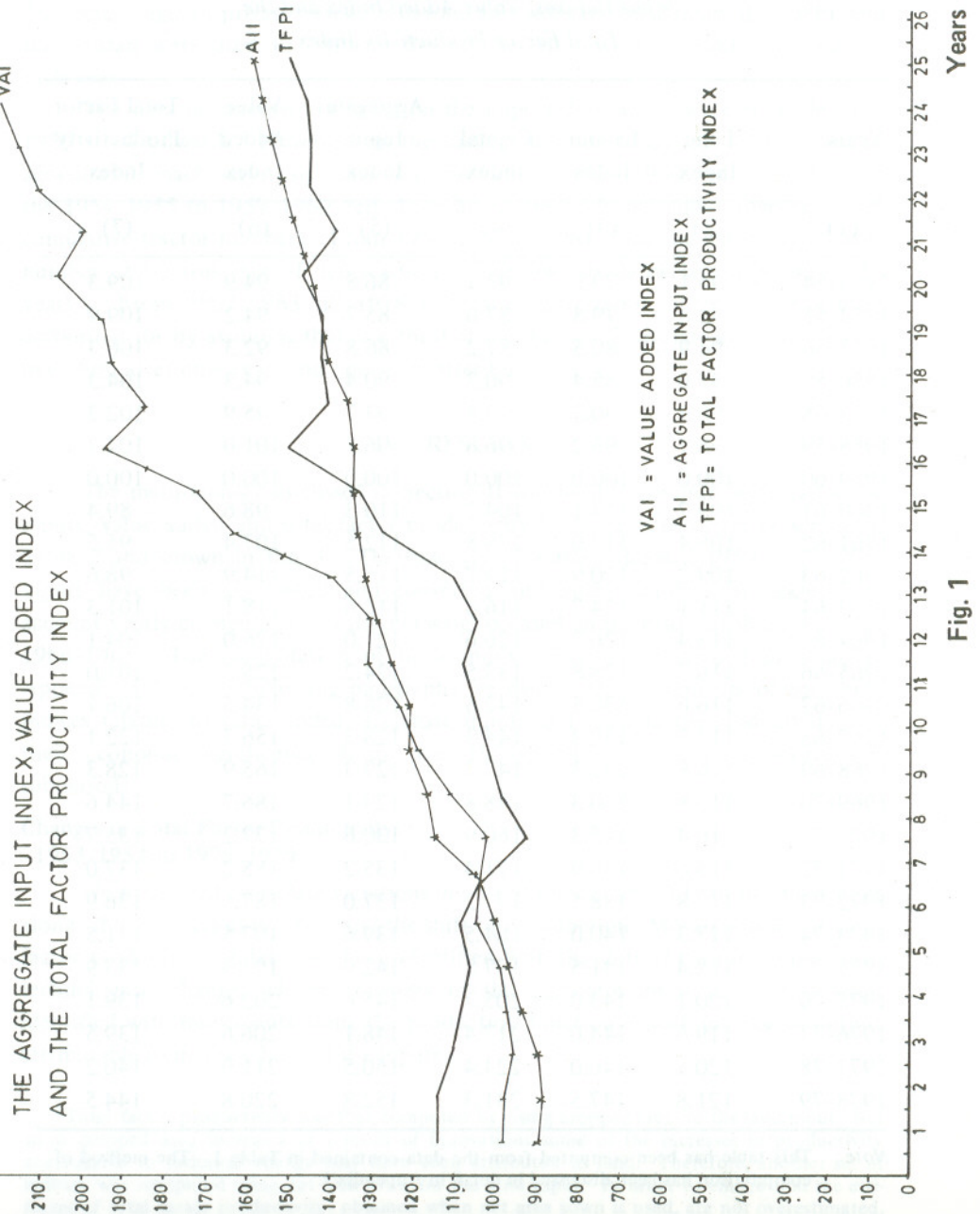

Fig. 1

The annual compound rates of growth of the value added index, the aggregate input index and the total factor productivity index during the period 1953-1954 to 1978-1979 are 3.4 percent, 2.3 percent and 1.1 percent respectively. Of the observed increase in value added, 67.6 percent was due to increased use of the inputs while 32.4 percent may have been due to technological change.[4] In the following paragraphs we have discussed in detail the behaviour of the three indices in the following five subperiods: (i) 1953-1954 to 1959-1960; (ii) 1959-1960 to 1964-1965; (iii) 1964-1965 to 1969-1970; (iv) 1969-1970 to 1974-1975; and (v) 1974-1975 to 1978-1979.

(i) *1953-1954 to 1959-1960*

During this subperiod, the aggregate input index increased at an annual compound rate of 2.4 percent, the value added index grew at the annual compound rate of 0.9 percent while total factor productivity declined at an annual compound rate of 1.5 percent. The decline in total factor productivity during this subperiod may have been due partly to reliance on traditional technology, partly to inadequate supplies of vital inputs such as water, and partly to disincentive effect of some government price policies and administrative controls.[5] The domestic prices of food grains such as rice and wheat were very low during this subperiod. Moreover, the administrative controls on agriculture introduced by the British government during the 1940s as wartime measures continued during the 1950s. 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.

(ii) *1959-1960 to 1964-1965*

During this subperiod, the agricultural sector started picking up slowly, when the compound rates of growth of the aggregate input index, the value added index and the total factor productivity index were 3.9 percent, 4.7 percent and 0.8 percent respectively. Of the observed increase in value added during this subperiod, 83.0 percent was attributable to the increased use of the inputs and the remaining 17.0 percent is unexplained residual.

[4] Of the observed increase in value added, the percentages assigned to technological change and increased use of the inputs have been estimated from the compound rates of growth of the value-added index, the aggregate input index and the total factor productivity index. The relative share of the compound rate of growth of the total factor productivity index in the compound rate of growth of the value-added index is the increase in output attributable to technological change, whereas the relative share of the compound rate of growth of the aggregate input index in the compound rate of growth of the value-added index shows the percentage of increase in output on account of increased use of the inputs.

[5] For a detailed discussion of the administrative controls on agriculture and price policies pursued by the governments during the 1950s, see Burki [2].

(iii) *1964-1965 to 1969-1970*

During this subperiod, the aggregate input index and the value-added index grew at the annual compound rate of 1.3 percent and 8.2 percent respectively, implying a growth rate of 6.9 percent for the total factor productivity index. Of the observed increase in value added during this subperiod only 15.9 percent may be identified with movements along the production function and as much as 84.1 with the shift of the function. The shift of the production function during this subperiod may be explained by the greater availability of irrigation water combined with the modern inputs like the high-yielding seed varieties and fertilizers. Public policy helped in the rapid diffusion of the modern inputs through generous subsidies on these inputs, favourable terms of exchange for imports of agricultural machinery and parts, and provision of cheap electricity for tubewells. The high and stable support prices of major agricultural crops helped to turn the terms of trade in favour of the agricultural sector [2; 6].

According to several studies, the increase in the supply of irrigation water was the single most important factor responsible for the breakthrough in agriculture. Additional supplies of water became available with the completion of the Mangla Dam, which helped to increase the acreage under winter crops. More important, however, was the installation of tubewells, particularly private tubewells, on a massive scale during this subperiod. The output-augmenting effects of tubewell water have been studied in detail by Kaneda and Ghaffar [11], Ghulam Mohammad [14] and Nulty [15] who observed that the increase in the supply of irrigation water led to increased use and efficiency of both the traditional inputs (like land, labour and livestock) and the non-traditional inputs (like chemical fertilizers).

Our analysis also shows that agricultural productivity started rising during the subperiod when increased supply of irrigation water was combined with other modern inputs like high-yielding seeds and fertilizers. According to Falcon and Gotsch [6] agricultural productivity started rising due to the 'interaction effect'.[6]

(iv) *1969-1970 to 1974-1975*

During this subperiod, the compound rates of growth of the aggregate input index and the value added index were 2.1 and 0.5 percent per annum respectively. Total factor productivity declined at the rate of 1.6 percent per annum during this subperiod, most probably because of unfavourable weather and political and economic instability during 1970-1972, floods in August-September 1973 and low canal water supplies and the Tarbela Dam mishap in 1974-1975 [21].

(v) *1974-1975 to 1978-1979*

In this subperiod, the agricultural sector started picking up once again with the aggregate input index growing at the compound rate of 1.7 percent per annum and

[6]They maintain that increases in output which are not accounted for by individual inputs can be explained by the interaction effect of using several inputs simultaneously.

the value added index at 3.7 percent per annum. Total factor productivity grew at the compound rate of 2.0 percent per annum. Of the observed increase in value added during this subperiod, 45.9 percent was attributable to movements along the production function while the remaining 54.1 percent was due to the shift of the function.

V. LIMITATIONS OF THE STUDY

The computation of total factor productivity estimated on the basis of value added might have introduced some bias since the deductions from total output to account for the current inputs may underestimate the real value of these inputs when these inputs have been valued on the basis of subsidized prices. But the extent of the bias is not very great and there is not much difference between the estimates of total factor productivity computed on the basis of value added from the ones computed in terms of total output. Laspayer's, Paasche's or Fisher's Ideal Index could not be computed due to the non-availability of data on factor prices. The year 1966-1967 was the first year for which prices of all the different inputs were available.

The study had to make compromises with whatever data were available. For example, the data on rents received by landlords and the capital cost of tubewells are for the Punjab only. This has been used as a proxy for Pakistan. Moreover, the data on agricultural labour force might not be very reliable, but in the absence of more reliable data, the existing data had to be used.

Another limitation of the study is that the data on different inputs are in stock terms rather than in flow terms. It is ideal to do the analysis in terms of flow-variables, but this was not possible due to the non-availability of data.

VI. POLICY IMPLICATIONS

One of the factors that may have been responsible for the poor performance of the agricultural sector during the 1950s was the administrative control of agriculture in the form of restrictive zoning of surplus areas and the compulsory sale of surplus foodgrains at prices which were less than the market prices [2]. Although these administrative controls have been removed, the existing administrative controls might still be having an adverse effect on agricultural output and productivity. In order to maintain the rate of growth of agricultural productivity it is imperative that these controls be reduced to a minimum.

Our analysis also brings out the importance of government price policies. For example, the decline in the productivity of the agricultural sector during the 1950s has been largely ascribed to the disincentive effect of unfavourable price policies of the government [2]. On the other hand, when the government adopted policy of high and stable support prices for major agricultural crops during the 1960s,

agricultural output and poductivity increased considerably [2; 6]. It is clear, then, that given favourable price incentive, the Pakistan farmer is quite capable of, as Schultz put it, "turning sand into gold".

According to several studies [11; 14 and 15] the increase in the supply of irrigation water due to the installation of private tubewells was a crucial factor in increasing agricultural output during the 1960s. The best encouragement that the government can give in this regard is to continue to make tubewell spare parts available and provide electric power and transmission lines to areas which still lack these facilities. These are the *barani* (rain-fed) areas where farmers are unable to use modern technology which requires adequate control over the supply of irrigation water. Increase in the number of tubewells in these areas will, on the one hand, increase the supply of irrigation water, and, on the other, enable the farmers to use the other biological and chemical innovation which they have hitherto not been able to use.

Moreover, further research needs to be conducted to capture the effect of weather on agricultural output and productivity. For example, we have yet to determine the role of weather in greater orientation towards agricultural modernization that has been going on since the 1960s.

VII. SUMMARY AND CONCLUSIONS

The main contribution of this paper is the computation of total factor productivity for the Pakistan agriculture. Our analysis shows that during the subperiod 1953-1954 to 1959-1960 the performance of the agricultural sector was quite poor, with total factor productivity declining at the annual compound rate of 1.5 percent. While there was some recovery during the second phase, 1959-1960 to 1964-1965, the performance of the agricultural sector was indeed spectacular during the third phase, 1964-1965 to 1969-1970, when the annual compound rates of growth of the value added index, the aggregate input index and the total factor productivity index were 8.2 percent, 1.3 percent and 6.9 percent respectively. During this subperiod only 15.9 percent of the observed increase in value added has been accounted for by the use of inputs and as much as 84.1 percent may have been due to technological change. However, this performance could not be maintained during the subperiod 1969-1970 to 1974-1975 when total factor productivity started declining. During the 1974-1975 to 1978-1979 subperiod there was some improvement once again.

Some of the factors that may have been responsible for the poor performance of the agricultural sector during the first phase were certain discouraging administrative controls and government price policies, inadequate supply of irrigation water and the use of traditional methods of production. The analysis shows that the remarkable performance of the agricultural sector during the third phase was a structural

transformation involving an upward shift of the production function. According to several studies, the remarkable performance of the agricultural sector during this phase was due to appreciable increase in investment in inputs like water, seeds and fertilizers. Public policy in terms of favourable prices for major agricultural crops and other incentives also played a very important role.

Our study concludes that to ensure desirable growth in total factor productivity in Pakistan's agricultural sector the existing administrative controls need to be minimised, high and stable support prices of major agricultural crops should be continued and farmers be given sufficient incentives to install tubewells. Furthermore, research should be carried out to determine how far modernization of the agricultural sector has reduced the dependence of the farmer on weather.

Appendix I

COMPUTATION OF INDEXES

Land Index

First the land input was roughly divided into four categories on the basis of the 1972 Agricultural Census [16]. The first category comprised farms under 7.5 acres which accounted for almost 12 percent of the farm area. The second category comprised farms between 7.5 acres and 25.0 acres. About 45 percent of the farm area belonged to this category. The third category included farm size group of 25.0 to 50 acres and accounted for 19 percent of the total farm area. The farm size of 50 acres and above comprised 24 percent of the farm area. The land area having been divided into these four categories, each category was multiplied by its respective rent in 1966-1967 (Appendix II). Rents received by these four categories were added for each of the years and converted into an index by taking 1959-1960 = 100.

Capital Index

The capital index is composite. It includes livestock, private and public tubewells and tractors. The private tubewell numbers were divided into electric and diesel by taking the average percentage share of electric and diesel tubewells in total private tubewells for the years 1969-1970 to 1977-1978, which were 31.9 percent and 68.1 percent respectively. The electric and diesel tubewell series were multiplied by their respective capital costs in 1966-1967. The capital costs on electric and diesel tubewells were added to get total cost on private tubewells for each of the years from 1953-1954 to 1978-1979.

Since most of the public tubewells are of four-cusec capacity as against the private tubewells which are generally of one-cusec capacity, the public tubewell series was multiplied by 4 to make it equivalent to private tubewells. The percentage shares of electric and diesel tubewells in total public tubewells were on the average 95.8 percent and 4.2 percent respectively for the five years from 1973-1974 to 1977-1978. These percentages were used to divide public tubewells into electric and diesel. These categories were then multiplied by the capital cost of electric and diesel tubewells. The total cost on public tubewells was added to the total capital cost.

Similarly, the draught animals were divided into cattle, buffaloes, camels, donkeys and horses on the basis of the percentage shares of these categories in total draught animals in the 1971-1972 to 1978-1979 period. The percentage shares are: cattle 70.9 percent, buffaloes 2.0 percent, camels 5.3 percent, donkeys 21.5 percent and horses 0.4 percent. This is how the entire draught animals series was sub-divided into these various categories. These series were then multiplied by their respective prices in 1967 (Appendix II). The cost on cattle, buffaloes, camels, horses and donkeys was added to get total cost on draught animals.

The tractor series was multiplied by the ex-Karachi selling price of a 45-horse-power Massey Ferguson tractor in 1966-1967.

For each year the total costs on draught animals, private and public tubewells, and tractors were added to get total capital cost during the 1953-1954 to 1978-1979 period. This series was then converted into an index by treating the year 1959-60 = 100.

Labour Index

For each year the labour input was multiplied by the farm wages in 1966-1967. The total cost on labour was then converted into an index.

Aggregate Input Index

The total costs on land, labour and capital for each year were added and converted into an aggregate input index.

Value-Added Index

Data on agricultural value added were converted into an index by treating the year 1959-1960 = 100.

Appendix II

FACTOR PRICES (in 1966-67) RELEVANT TO THE FACTOR SHARE WEIGHTS

Land

Rents Received by Landlords by Size of Holding in the Punjab

Rs. (per acre)

Less Than 10 Acres	10–25 Acres	26–50 Acres	51–100 Acres	101–250 Acres	251–500 Acres
94	128	160	152	148	132

Labour. Wages of Hired Agricultural Labour = Rs. 2.48 Per Day.

Capital

Capital Cost of Private Tubewells

	Gujranwala/Sialkot Region	Multan/Sahiwal Region	Average of the Two Regions
Electric Tubewells	Rs. 6,000	Rs. 9,164	Rs. 7,582
Diesel Tubewells	Rs. 9,322	Rs. 12,464	Rs. 10,893

Draught Animals

Price Per Animal

Cattle	Rs. 438.73
Buffaloes	Rs. 285.66
Camels	Rs. 571.84
Horses	Rs. 612.57
Donkeys	Rs. 104.06

Tractor. The ex-Karachi Selling Price of a 45-Horsepower Massey Ferguson Tractor = Rs. 12,585.78.

Sources: The data on rent are from [2].
The data on agricultural wages are from [7].
The data on the capital cost of private tubewells are from [15].
The data on prices of agricultural animals are from [18].
The data on the prices of tractors are from the ADBP unpublished data.

Appendix II Table 1

Factor Share Weights

Years	Land	Labour	Capital
1953-54	38.8	42.9	18.3
1954-55	38.7	43.8	17.5
1955-56	34.1	47.2	18.7
1956-57	38.4	44.4	17.2
1957-58	37.5	45.3	17.2
1958-59	36.3	46.4	17.3
1959-60	35.8	47.0	17.2
1960-61	35.6	48.2	16.2
1961-62	34.5	48.9	16.6
1962-63	33.5	48.8	17.7
1963-64	32.5	50.3	17.2
1964-65	32.7	49.3	18.0
1965-66	32.8	48.7	18.5
1966-67	32.2	48.4	19.4
1967-68	32.1	48.5	19.4
1968-69	32.7	47.7	19.6
1969-70	37.3	47.4	15.3
1970-71	30.1	48.7	21.2
1971-72	30.6	47.6	21.8
1972-73	30.2	47.5	22.3
1973-74	30.0	47.2	22.8
1974-75	29.6	46.6	23.8
1975-76	29.5	46.2	24.3
1976-77	28.8	45.9	25.3
1977-78	28.7	45.6	25.7
1978-79	28.5	45.4	26.1
Average for 26 years:	33.1	47.1	19.8

Note: This Table has been computed by multiplying the physical quantities of the inputs (Table 1) by the Factor prices (Appendix II).

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