Total Factor Productivity Growth in Pakistan's Agriculture: 1960-1996

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1.INTRODUCTION

Agriculture in Pakistan faces considerable challenge in the 21st century. The present population of about 137.5 million, growing at about 2% per year, is expected to double to 275 million in 35 years. Pakistan's agriculture has experienced rapid growth since the 1960s. The average annual growth of about 4% over the last four decades has exceeded the population growth rate of about 2.8 %. This rate of growth in agriculture has been sustained by the technological progress embodied in the high-yielding varieties of grains and cotton with supporting public investment in irrigation, agricultural research and extension (R&E), and physical infrastructure. Agricultural growth, in turn, has made significant contribution to the overall economic growth of about 6% per year during this period. Despite rising per capita income, food demand is likely to grow rapidly given the low level of current per capita income. Recent projections for future food supply and demand, call for sustained efforts for increasing production of essential items (wheat, edible oils, etc.). Faced with limits to further expansion of cultivated land and slowing returns to further input intensification, productivity growth assumes a central role in meeting the challenges of the future.

The most comprehensive measure of aggregate or sectoral productivity is Total Factor Productivity (TFP). However, given the paucity of good data, this area of research has remained quite limited in Pakistan. There have been only few studies so far and all of them, with the exception of Khan (1997), have used the data on crop production, excluding livestock. In the present study, the TFP change in Pakistan's agriculture sector, including crops and livestock, is estimated for the period 1960-61 to 1995-96 using improved notions of output and inputs measures.[1] Since no official agency in Pakistan maintains a TFP index for the agriculture sector, no effective mechanism exists for monitoring changes in the efficiency of resource use in agriculture on a regular basis and assessing the sustainability of various policy approaches. This study, therefore, would provide a fresh perspective on the growth of TFP in agriculture for use in developing appropriate policy responses towards this sector of Pakistan's economy.

2. AGRICULTURE AND THE ECONOMY

Nearly one-quarter of Pakistan's Gross Domestic Product (GDP) is contributed by the agriculture sector and it employs nearly 44 % of the labor force. Agricultural exports directly and indirectly, make up a large proportion of total exports and foreign exchange earnings of the country (Table 1). While the share of agriculture in the economy has been decreasing relative to that of industry—from 48.7 % in 1951/52 to 25.6 % in 1998/99—its performance can still have a major impact on the overall economic growth because of its linkages with the rest of the economy. The periods of high/low agricultural growth have generally coincided with periods of robust/poor performance of the national economy (Table 2.). For example, relative agricultural stagnation in the 1950s and 1970s constrained overall economic growth in the economy. In the 1960s, an impressive

[1] The choice of this period for study is premised on the fact that as a result of policy neglect of agriculture, no significant productivity growth occurred in Pakistan's agriculture before the 1960s.

performance of agriculture, propelled by the introduction of the new seed-water-fertilizer technology, facilitated the economy in attaining its highest growth rates. Similarly, in the 1980s and 1990s, despite considerable decline in the sector's contribution to GDP, it has had a sizeable influence on overall economic growth. The relationship between agriculture and the overall economy is brought home even more sharply during years of abnormal weather or natural calamities. The damage suffered by agriculture during these periods never fails to have a significantly adverse effect on the overall growth of GDP.[2]

Table.1 Contributions of Agriculture Sector to Pakistan's Economy, Selected Years

Year	GDP Share (%)	Employment Share (%)	Total Exports (Rs. Million)	Direct Agri-exports (Rs. Mill)	Indirect Agri-exports in total exports (Rs mill)
1951/52	48.7	N/A	922	818 (88.7)	N/A
1961/62	42.8	60	543	351.6 (64.7)	43.7 (8.0)
1971/72	37.6	57	3371	1385 (41.0)	1299 (38.5)
1981/82	28.7	53	26270	7974 (30.3)	10073 (38.3)
1991/92	26.1	48	171728	26341 (15.3)	94039 (54.7)
1998/99	25.6	44	390342	33251 (8.5)	210327 (53.8)

Source: Ministry of Finance, Economic Survey and statistical supplements.

Note: Direct Exports include fish and fish preparations, rice, hide and skins, raw cotton and raw wool. Indirect exports include cotton waste, leather, cotton yarn, cotton thread, cotton cloth, footwear, tobacco and tobacco products, guar and products, readymade garments and hosiery, carpets and rugs, and sports goods. Numbers in parenthesis are percentage shares in direct and indirect agricultural exports.

[2] "--the rains and flooding that occurred in the summer of 1992 destroyed about 10 per cent of the sugarcane crop, 15 percent of cotton and rice crops, and an even greater portion of smaller-scale food crops. As a result, agricultural exports plummeted and were largely responsible for the 3.2 percent drop in GDP that year. In 1994, a crop virus reduced cotton yields, and wheat yields were lower due to an unusually warm and dry winter. These events are expected to depress growth" (Faruqee 1995, p.8).

Table 2.Growth Rates of GDP and Value of Agricultural Output, Pakistan 1950-2000

	Average Annual Rate of Changes (%)	
	GDP	Agricultural value-added
1950-55	3.4	1.4
1955-60	3.1	2.1
1950-60	3.2	1.7
1960-65	6.8	3.8
1965-70	6.8	6.4
1960-70	6.8	5.1
1970-75	4.5	0.8
1975-80	6.6	3.9
1970-80	5.5	2.4
1980-85	6.7	3.8
1985-90	5.6	4.4
1980-90	6.1	4.1
1990-95	5.1	4.2
1995-2000	4.1	4.6
1990-2000	4.5	4.4
1960-2000	5.7	4.0

Source: Khan (1997) Table1, and Economic Survey 1999-2000.

3. STUDIES OF TFP MEASUREMENT IN PAKISTAN AGRICULTURE

There have not been many studies measuring TFP growth in Pakistan agriculture. Wizarat (1981), in a pioneering study of changes in agricultural productivity for the period 1953/54 to1978/79, computed arithmetic TFP index in a growth accounting framework using the linear production function approach. While reflecting the broad contours of productivity change over the sample period, there are serious data and methodological limitations in the study.[3] In addition**,** the study only focuses on the crop sector whereas livestock output also contributes importantly to total agricultural

[3] An arithmetic index, derived from a linear production function, assumes perfect substitutability between inputs. The use of a value-added output index implies the existence of a value-added function, which apart from the separability restrictions excludes the role of intermediate, purchased inputs. In addition, the capital input variable has been constructed as a stock whereas a service flow concept would be the more appropriate.

production. Khan (1994), also using an arithmetic index, formulation, estimated TFP growth for the crop subsector during 1980-93. Compared with annual TFP growth of 2.74% in Wizarat's study, Khan (1994) estimates annual TFP growth at 1.87% (Table 3).

Table3. TFP Growth in Pakistan Agriculture,1960-96.

Year	AgriculturalGDP (1980-81 prices)	Wizarat (1981)	Khan (1994)	Khan (1997)
Average Annual Growth Rate(%)				
1960-65	4.59	3.70		1.3
1966-70	7.84	9.50		4.5
1960-70	5.19	4.70		2.2
1971-75	2.00	0.06		0.1
1976-80	3.65	1.20		0.0
1971-80	2.62	0.57		-0.1
1981-85	2.85		0.66	0.7
1985-90	4.12		1.19	0.6
1981-90	4.12		1.56	0.8
1991-93			3.97	
1991-96	3.69			
Total Period				
1960-79	3.71	2.74		
1981-93			1.87	
1960-96	3.75			0.8

Note: Wizarat(1981) and Khan (1994) use arithmetic index; Khan (1997) uses T.T index

Using the Tornqvist-Theil (T.T) methodology, Rosegrant and Evenson (1993) have estimated the TFP growth for the period 1956-1985 in the crop sector, using disaggregated data covering 35 districts in three provinces. TFP, in their study, grew

Table 4. Annual Rates of Growth of TFP in Crops , 1956-85

	1956-85	1956-65	1965-75	1975-85
Pakistan	1.07	1.65	1.86	-0.36
Pakistan Punjab	1.06	1.42	2.13	-0.84

Source: Rosegrant and Evenson (1993). period (1965-75)

rapidly in the early Green Revolutionat a rate of 1.86% percent per annum but, rather surprisingly, declines very sharply thereafter (Table 4.). Furthermore, TFP growth is found to have accounted for about one-third of total output growth over the period of study.[4] Both Wizarat (1981) and Khan (1994, 1997), on the other hand, find TFP growth in the post-1975 period to have been positive and improving after a period of stagnation in the first half of the 1970s (Table 3). One reason for the conflicting results may lie in the unreliable data-set used by Rosegrant and Evenson (Khan 1997, p.311). The study carries no explanation for the panel data set covering 35 districts and 30 year period (1955-85) since the official documents do not report the data at this level of disaggregation for many of the variables (inputs) used in the analysis.

4. MEASUREMENT OF TOTAL FACTOR PRODUCTIVITY GROWTH IN PAKISTAN'S AGRICULTURE

Arithmetic Index

The simplest measure of TFP for the agriculture sector is the arithmetic index, defined as a ratio of the total output index to input index, with the input index constructed as a linear aggregation of inputs with input shares in total input cost as weights.[5] Following Wen (1993), the simplest version of a TFP Index can be algebraically written as: The index can be easily derived assuming a linear homogenous production function and competitive labor markets. Despite its theoretical limitations, it is the easiest to calculate.

$$\text{TFPI} = \frac{100 \times (\text{GVAO Index})}{\alpha(\text{ Lan Index}) + \beta(K \text{ Index}) + \delta(\text{Lab Index}) + \phi(\text{M Index})} \quad (1)$$

where the output index in the numerator is based on the Gross Value of Agricultural Output (GVAO). The input index in the denominator is a linear aggregation of cultivated

[4]The determinants of TFP growth are also analyzed by decomposing the productivity residual using regression techniques. They find that agricultural research, high yielding varieties (HYVs), literacy, and share of irrigation are the major sources of TFP growth.

land (Lan), capital (K), labor (Lab), and material inputs (M), using $\alpha, \beta, \delta,$ and ϕ (the respective share of each factor input in total input cost in the base year) as weights.[6]

In this study, the TFP index for the period 1960-96 is computed with a gross output index that includes both crops and livestock products and the aggregate input index that also includes purchased inputs (fertilizers and pesticides).[7] Capital input, which includes tractors, irrigation tube wells, and work animals, has been defined as a flow of services. The output and input indices are set at 100 for the year 1960-61.

Table 5. TFP Changes with Arithmetic index, 1960-96

Year	GVAO	TFP 1960-61 weights	TFP 1980-81weights
Annual Average Growth rates(%)			
1960-65	4.90	2.97	2.67
1966-70	7.12	6.26	3.49
1960-70	5.18	3.99	2.78
1971-75	2.24	0.93	-0.59
1976-80	4.31	1.97	-0.30
1971-80	3.11	1.07	-1.20
1981-85	3.15	2.00	0.61
1985-90	3.92	2.05	1.69
1981-90	4.32	2.43	0.63
1991-96	3.72	1.62	0.50
Total period (1960-96)	3.85	2.17	0.40

Note: GVAO is gross value of agricultural output at 1980-81 prices (Kemal and Islam 1992)

[5] The index can be easily derived assuming a linear homogenous production function and competitive labor markets. Despite its theoretical limitations, it is the easiest to calculate.
[6] There are two measures of land available in the official statistics of Pakistan—cultivated land and cropped land. TFP studies of agriculture have used one or the other measure in their analyses (Hayami and Ruttan 1979; Fernandez-Cornejo and Shumway 1997; and Wen 1993). In the present study, cultivated land has been chosen as the appropriate measure of land input to keep the land input separate from the land-augmenting technological changes subsumed by cropped land. Both the arithmetic and T-T productivity indices give higher annual rates of growth with cultivated land than with cropped land. Productivity growth is lower with cropped land (arithmetic index 1.8%, T-T index 2%) as some of the output growth is due to multiple cropping.
[7] Wizarat (1981) and Khan (1994) have also used an arithmetic index for analyzing productivity change in the crops sector in Pakistan, but for subperiods of the period in this study and with a restricted set of inputs and variable definitions. Both authors have used a value-added index for the crops subsector and, therefore, were not able to include purchased inputs in their calculations.

The estimated annual growth rates of agricultural GDP and arithmetic TFP (at 1960-61 and 1980-81 weights) are given in Table 5. The highest growth rate of TFP is in the early Green Revolution period (1965-70) and the lowest in the 1971 to 1975 period. For other periods, the estimated index calculated with 1960-61 shares performs relatively better as the sub-period growth rates as well as the TFP growth rate for the entire period appear to be more reasonable. The major drawback of this indexing procedure, however, is that the index is sensitive to the choice of factor shares, as is revealed by a change in factor shares from the 1960-61 base to 1980-81 base.[8] Applying the 1980-81 factor shares to the earlier period overstates the contribution of labor, farm capital, and current inputs and understates the role of land, thus depressing the TFP growth in the early part of the sample period. Since the choice of weights affects the TFP estimates in the arithmetic index method, it has been replaced by indices like the Divisia index.

Tornqvist-Theil Index

The Tornqvist-Theil (T-T) approximation to the Divisia index for TFP is usually used in empirical work. The most frequently used formulation is (Chambers 1988; Capalbo and Antle 1988 ; Thirtle and Bottomley 1992) :

$$\ln(TFP_t / TFP_{t-1}) = 1/2\sum_i (R_{it} + R_{it-1})\ln(Y_{it} / Y_{it-1}) - 1/2\sum_j (S_{jt} + S_{jt-1})\ln(X_{jt} / X_{jt-1}) \qquad (2)$$

where R_{it} is the share of output i in total revenue, Y_{it} is output i, S_{jt} is the share of input j in total input cost, and X_{jt} is input j, all in period t. In this specification, revenue shares

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[8] The factor input shares in total input cost for 1960-61 and 1980-81 are:

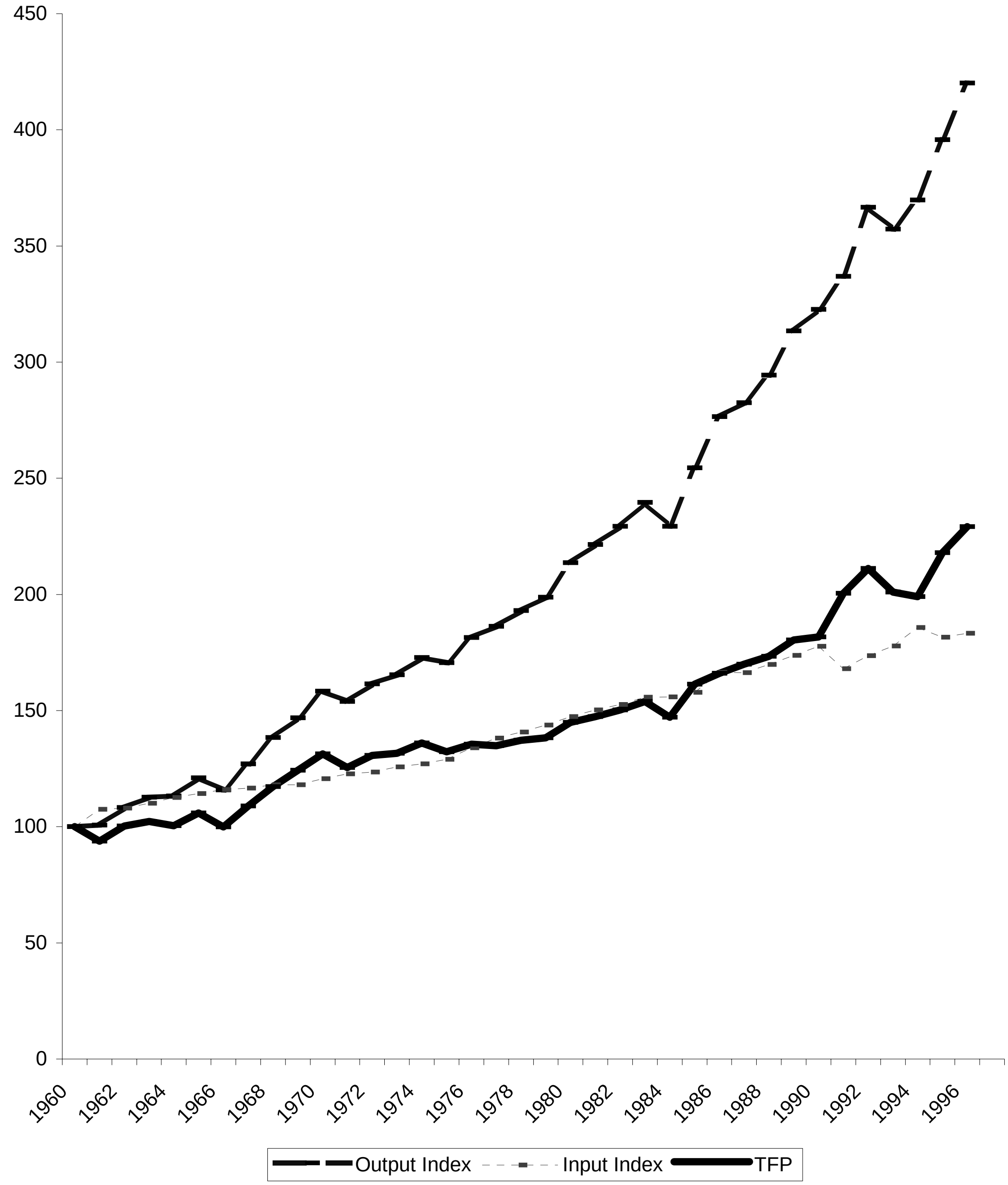
	1960-61 weights	1980-81 weights
Land	0.382	0.305
Labor	0.577	0.596
Farm Capital	0.035	0.054
Current Inputs	0.004	0.044

for the output index and cost shares for the input index are updated every time period as compared with the use of fixed weights in the arithmetic and geometric indices, thus avoiding the underestimation/overestimation implicit in a fixed-weight estimation procedure.

Table 6. Indices of Agricultural GDP, Output, Input and TFP, 1960-1996

Year	Agricultural GDP (1980-81 prices) Index	Output Index (T-T)	Input index (T-T)	TFP Index (T-T)
1960	100.0	100.0	100.0	100.0
1961	99.8	100.7	107.4	93.7
1962	106.0	108.3	108.0	100.3
1963	111.5	112.7	110.1	102.3
1964	114.3	113.2	112.6	100.5
1965	120.3	121.0	114.2	105.9
1966	120.9	115.8	116.0	99.9
1967	127.5	127.0	116.6	109.0
1968	142.4	138.3	118.0	117.2
1969	148.9	146.9	118.1	124.4
1970	163.1	158.4	120.6	131.3
1971	158.1	153.9	122.7	125.4
1972	163.6	161.5	123.6	130.7
1973	166.3	165.4	125.7	131.6
1974	173.2	172.8	127.0	136.1
1975	169.6	170.6	129.0	132.2
1976	177.1	181.4	133.9	135.5
1977	181.6	186.3	138.1	134.9
1978	186.3	193.1	140.8	137.2
1979	192.7	198.8	143.7	138.3
1980	205.7	213.6	147.4	144.9
1981	212.8	221.5	150.3	147.4
1982	222.8	229.3	152.6	150.3
1983	232.6	239.6	155.7	153.9
1984	221.4	229.3	155.8	147.1
1985	245.6	254.5	157.8	161.3
1986	260.2	276.5	166.5	166.1
1987	268.7	282.5	166.3	169.9
1988	276.0	294.3	169.8	173.3
1989	295.0	313.4	173.7	180.4
1990	303.9	322.7	177.6	181.7
1991	319.0	336.9	168.1	200.5
1992	349.3	366.6	173.6	211.2
1993	330.8	357.2	177.7	201.0
1994	348.1	369.7	185.7	199.1
1995	371.0	395.8	181.6	218.0
1996	392.5	420.2	183.3	229.2

FIG. 1 OUTPUT, INPUT and TFP Indices, 1960-1996.



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5. RESULTS AND INTERPRETATION

Using the T-T indexing procedure, the estimated values of indices of output, input, and TFP are shown in Table 6. The output and input indices are based on the output and input aggregators defined in Eq. (2), taking the exponents and chaining them.[9] The output index includes important major and minor crops and livestock products.[10] The input index is constructed with land, labor, tractors, tube wells, work animals, and purchased inputs (fertilizer and pesticides). A detailed discussion of the conceptual and practical issues relating to the data used in the study is given in the appendix.

Table 7.. Annual Average Growth Rates (%) of Agricultural GDP, Output, Input, and TFP,1960-96

Year	Agricultural GDP(1980-81 prices) Index	Output Index	Input index	TFP Index
1960-65	4.0	3.9	2.4	1.5 (38)
1966-70	7.8	8.0	0.9	7.0 (87)
1960-70	4.9	4.5	1.6	2.8 (62)
1971-75	2.0	2.8	1.3	1.5 (53)
1976-80	3.6	4.0	2.4	1.6 (40)
1971-80	2.6	3.4	2.2	1.2 (35)
1981-85	2.8	2.8	1.2	1.6 (57)
1985-90	4.1	4.2	1.7	2.4 (57)
1981-90	4.1	4.5	1.9	2.6 (58)
1991-96	3.7	4.0	1.8	2.2 (55)
Total period (1960-1996)	3.7	4.0	1.7	2.3 (58)

Note: The numbers in parentheses in the last column are the percent contribution of productivity growth to output growth.

[9] Chaining of the index involves calculating each value relative to the previous observation, rather than relative to a single base year.

[10] The major crops included are wheat, rice, cotton, sugarcane, maize, bajra, jowar, barley, and gram. The minor crops included are mung, mash, masoor, potatoes and onions.

As shown in Table 7, the estimated TFP growth rates for the period under consideration clearly indicate a strong performance in the second half of the1960s. This corresponds with the beginning of the Green Revolution as the hybrid varieties of rice and wheat were introduced in Pakistan during this period. Growth in productivity tapered off in the first half of the 1970s as a result of the politically-induced institutional experiments, drought conditions in 1970-72, and the heavy rains and accompanying floods in 1973-74, amongst others. There was a slow and gradual recovery in productivity growth in the late 1970s and the early 1980s, with the exception of a brief downturn in 1983-84 largely due to adverse weather. Thereafter, an annual TFP growth rate of 2.4 % has been sustained, barring a dip in 1992-93 due to adverse weather and large-scale pest attack on cotton. While the productivity gains in the 1980s and 1990s were much lower than the impressive growth experienced in the early Green Revolution years (1965-70), they still reflect a fairly robust performance by agriculture. The estimates show that TFP has grown at an average annual rate of 2.3% for the entire period (1960/61 to 1995/96) with 58% of the total output growth attributable to productivity growth. It is fair to say that productivity growth was a significant driving force in the performance of the agriculture sector in Pakistan for over 36 years. According to Byerlee (1994) “Over the long-run, evidence from a number of countries suggests that an overall rate of agricultural productivity growth of 1.5-2.0 percent can be expected (as measured by the TFP index).”(p.10) This a priori expectation is reasonably met by the estimated TFP growth rate of 2.3% per year during the entire period in this study. This estimate, furthermore, falls within the general range of TFP growth rates estimated in studies for other developing economies (Table 8).

Table 8. Estimates of Total Factor Productivity Growth in Developing Economies

Study	Country/Period of Study	Estimation Methodology And Nature of Data	Average annual TFP Growth Rate
Hayami and Ruttan (1979) (These results are for the TFP index calculated with total output instead of value added.)	Japan 1876-1969 Korea 1920-1969 Taiwan 1913-1970 Philippines 1950-1969	Arithmetic index / annual Time Series	0.8% 0.52% 0.7% 0.7%
Wizarat (1981)	Pakistan (1953-1979)	Arithmetic index / annual Time Series	1.1%
Wong (1989)	India China (1964-83)	Geometric Productivity index / annual time series	China : -3.86% India : -1.63 %
Evenson and Rosegrant (1993)	Pakistan India (1956-1985)	T-T index. Cross-section districtwise / annual time series	Pakistan:1.07% India: 1.01%
Thirtle et.al (1993)	Zimbabwe Commercial Sector (1970-90) Communal Sector(1975-90)	T-T index / annual time series	Commercial sector: 3.43% Communal Sector: 4.64%
Khan (1994)	Pakistan (1980-1993)	Arithmetic index / annual time series	2.1 %
Khan (1997)	Pakistan (1960-1996)	T-T index / annual time series	0.92%
Fernandez-Cornejo and Richard Schumway (1997)	Mexico (1940-1990)	T-T index / annual time series	2.5 %
Evenson, Pray and Rosegrant (1999)	India 1956-1987	T-T index / Cross-section districtwise / annual time series	1.3%

Table 9.Changes in Crop Output, Crop Yields, Barter Terms of Trade and Important Inputs, 1964/65-1975/76.

Year	Index of Crop Production (1959/60 =100)	Wheat Yield (kg/h)	Rice Yield (kg/h)	Sugar Cane (kg/h)	Cotton (kg/h)	Net Barter Terms of Trade (1959/60 =100)	Water Avail-ability (MAF)	Fertilizer Off take (000 N/T)
1964/65	128	863	996	37113	258	104.6	N/A	87.20
1965/66	127	760	945	37369	265	104.5	63.87	70.49
1966/67	135	811	969	33818	286	101.7	67.54	111.83
1967/68	157	1073	1056	37024	290	99.4	68.54	190.43
1968/69	168	1074	1307	40612	303	96.6	72.79	244.64
1969/70	186	1171	1480	42532	305	97.7	75.50	307.70
1970/71	174	1083	1464	36426	313	99.4	69.95	283.20
1971/72	183	1189	1554	36165	361	102.4	71.10	379.20
1972/73	188	1246	1574	37354	349	108.7	81.17	436.20
1973/74	196	1248	1624	37014	357	109.7	80.06	402.90
1974/75	187	1320	1443	31563	312	107.0	88.02	425.50
1975/76	199	1422	1531	36496	277	108.8	85.95	550.60

Note: The terms of trade index is the three year moving average computed by Qureshi (1987) using Lewis and Hussain methodology (1966) and 1959/60 weights. Water availability is measured in million acre-feet (MAF).

Table 10. Change in Yield Levels of Major Crops and Important Inputs, 1977-1998

	Wheat (kg/h)	Rice (kg/h)	Cotton (kg/h)	Sugar Cane (kg/h)	Cropped Area (million hectares)	Water Availability (MAF)	Credit Disbursed (Rs. (million.)	Fertilizer Off take (000'M/T)
1977-80	1457	1583	304	37075	19.21	89.32	2285	879.2
1980-83	1628	1697	347	37841	19.72	98.54	5065	1134
1983-86	1658	1632	396	36496	20.06	103.7	10443	1322
1986-89	1719	1635	547	40198	20.74	112.2	15416	1747
1989-92	1885	1539	648	41883	21.66	119.6	14428	1888
1992-95	1973	1675	529	45304	22.15	127.45	18081	2159
1995-98	2103	1872	545	46925	22.77	128.35	24042	2524

Source: Economic Survey, Agricultural Statistics of Pakistan. Note: kg/h is kilogram per hectare and MAF is million acre feet.

As Table 11. Agricultural Performance, 1977/78-1990/91.

Year	GDP (%)	Agric-ultural GDP (%)	Livestock GDP (%)	Index of Agricultural Production (1975/76=100)			Net Barter Terms of Trade		
				All	Food	Fiber	Total	All Crops	Livestock
1977/78	7.7	2.8	3.40	106	101	112	N/A	N/A	N/A
1978/79	5.5	3.1	3.41	109	114	92	N/A	N/A	N/A
1979/80	7.3	6.6	3.36	121	118	142	N/A	N/A	N/A
1980/81	6.1	3.6	3.53	125	122	139	100	100	100
1981/82	7.6	4.7	3.13	130	123	146	111.08	113.75	105.84
1982/83	6.8	4.4	4.3	136	133	160	108.05	107.36	112.10
1983/84	4.0	-4.8	5.9	118	122	96	107.10	107.73	111.38
1984/85	8.7	10.9	6.1	139	128	196	108.18	105.92	117.52
1985/86	6.4	5.9	6.2	147	133	237	103.88	99.14	119.04
1986/87	5.8	3.2	5.7	151	132	257	100.45	92.87	117.34
1987/88	6.4	2.7	5.6	160	132	297	105.73	95.36	133.15
1988/89	4.8	6.8	5.9	168	145	277	107.63	98.97	131.57
1989/90	4.5	3.0	6.1	168	146	283	101.20	90.27	128.38
1990/91	5.5	4.9	5.0	176	148	319	102.73	93.83	126.64

Source: Pakistan Economic Surveys, Agricultural Statistics of Pakistan and Salam (1992). Note: the GDP and agricultural GDP figures are the real annual growth rates.

As shown in Tables 9 &10, the yield growth for wheat and rice, after a peak performance in the early Green Revolution years, slowed after the mid-1970s. On the other hand, cotton, which contributed about 20% to the value added of major crops in 1980-81—its share rising to 30% in 1985-86—has done remarkably well in the same period, touching its highest yield growth of over 5 % per annum in the post-1985 period. Sugarcane, which makes up about 13% of the value-added of major crops, also began to experience improvement in its yield level in the post 1985 period, after a long period of stagnation. Above all, performance of the livestock sector, which constitutes about 30% of the agricultural GDP, has been improving since the early1980s, growing at an annual rate of 5% since 1985 (Table 11). Against this background, it is probably the case that the remarkably sustained productivity performance of agriculture in the post 1985 period, apart from the likely beneficial impact of the structural adjustment policies on agriculture, is a result of gains in the productivity of cotton and livestock more than offsetting the apparent productivity slowdown in wheat and rice crops.[11]

Table 12. Terms of Trade of Agriculture Sector in Pakistan, 1990/91 –1999/2000

Year (1)	F (2)	M (3)	Ratio (4)	F+R (5)	M+F+C (6)	Ratio (7)	BTOT (8)	Index (9)	ITOT (10)
1990-91	100.00	100.00	1.00	100.00	100.00	1.00	100.00	100.00	100.00
1991-92	110.87	108.15	1.03	109.75	108.23	1.01	101.00	109.50	110.60
1992-93	122.64	112.80	1.08	121.71	111.35	1.09	109.00	94.71	103.23
1993-94	139.68	131.47	1.06	147.45	129.36	1.14	114.00	105.23	119.96
1994-95	164.77	151.55	1.09	171.91	149.48	1.15	115.00	106.57	122.56
1995-96	184.13	164.94	1.11	186.30	166.62	1.12	112.00	111.72	125.13
1996-97	205.94	184.62	1.12	210.92	190.23	1.11	111.00	100.12	111.13
1997-98	220.78	189.17	1.17	226.78	199.92	1.13	113.00	104.52	118.11
1998-99	235.68	195.02	1.21	245.89	209.23	1.18	118.00	101.95	120.30
1999-00	236.82	203.80	1.16	231.99	217.07	1.07	107.00	105.54	112.93

Notes:

1. Column 2: ‘F’ is the price index of food.
2. Column 3: ‘M’ is the price index of manufactures.
3. Column 4: F/M Ratio.
4. Column 5: ‘F+R’ is the combined price index of food and raw material.
5. Column 6: ‘M+F+C’ is the combined price index of manufactures, fuels , and construction
6. Column 7: (F+R)/(M+F+C) Ratio.
7. Column 8: Barter Terms of Trade (BTOT) of agriculture (Column 7 × 100).
8. Column 9: Index of agricultural production (output).
9. Column 10: Income Terms of Trade (ITOT) of agriculture (Column 8 × 100).

Table13. Relative Purchasing Power of Major Crops in Pakistan, selected years

Year	Wheat		Cotton (Seed)		Sugarcane		Rice IRRI 6 (paddy)		Rice Basmati (paddy)	
	U	DAP	U	DAP	U	DAP	U	DAP	U	DAP
1990-91	1.39	1.78	0.60	0.77	10.26	13.11	2.13	2.72	1.09	1.39
1994-95	1.18	1.90	0.44	0.72	9.22	14.86	1.83	2.95	0.89	1.44
1999-00	0.86	1.73	0.33	0.64	7.39	14.75	1.40	2.80	0.74	1.48

Note: Purchasing power is measured in terms of crop output (in kgs) required to purchase one kg. of Urea and DAP (phosphate fertilizer)

[11] A number of studies have sounded alarm about productivity stagnation in Pakistan’s crop sub-sector in the post-Green Revolution period (Evenson and Rosegrant 1993; World Bank1994). The results of this study, however, offer no basis for an alarmist scenario as the performance of agriculture—crops and livestock—has been fairly robust since the mid-1980s.

Table 14. Macroeconomic Indicators and Performance of the Agriculture Sector, 1990/91 to 1997/98

	GDP (%)	Agric Value Added (%)	Budget deficit (%) of GDP (market prices)	Public expenditure in agriculture (ADP) million rupees	Real Effective Exchange Rate Index (1990=100)	Nominal Effective Exchange Rate Index (1990=100)
1985-86	6.4	5.9	8.1	4435	146.88	143.75
1986-87	5.8	3.2	8.2	3221	124.71	120.54
1987-88	6.4	2.7	8.5	3493	112.02	109.17
1988-89	4.8	6.9	7.4	3990	112.59	108.17
1989-90	4.6	3.0	6.6	3012	103.13	103.45
1990-91	5.6	5.0	8.7	3042	97.55	95.34
1991-92	7.7	9.5	7.4	3692	94.42	89.98
1992-93	2.2	-5.3	8.0	3461	99.07	91.15
1993-94	4.5	5.2	5.9	2164	93.58	83.50
1994-95	5.2	6.6	5.6	2004	94.65	79.78
1995-96	6.8	11.7	6.4	1561	91.45	71.73
1996-97	1.9	0.1	6.4		87.46	63.12
1997-98	4.3	3.8	7.7			
1998-99	3.2	1.9	6.1			

Source: Pakistan Economic Survey. Note: The nominal effective and real effective exchange rate indices are from Hasan (1998), Table 7.2 (p.339). The Index numbers relate to 4th quarter of the first year of the yearly intervals. Note: The GDP and Agricultural Value Added are real growth rates in percent per annum.

Despite the considerable short-term stress of structural adjustment and reform policies of the 1980s and the early 1990s, agriculture in Pakistan appears to have demonstrated remarkable resilience in the 1990s: the agricultural value-added has grown at an average annual growth of over 4 % (Table 14). It should be noted that the input supply grew steadily (Table 10) and the terms of trade for agriculture improved consistently during this period (Table.12). Farm profitability appears to have improved due to favorable prices for the main crops throughout the 1990s. This improvement in incentives is also reflected in the purchasing power of crops in terms of N and P fertilizers (Table 13).Adjustments in the nominal and real exchange rates and reform of trade policy have resulted in gradually falling discrimination against agriculture. This improving incentive regime for the farmer has been a significant factor in the sustained productivity response of agriculture during the 1990s.

CONCLUSION

Pakistan's agriculture has managed a satisfactory average annual growth rate of about 4 % since the 1960s, despite structural and institutional rigidities and a policy environment that has not always been very supportive. Sustaining this performance is essential to meet the food demand of a growing population and raw material requirement of expanding industry. The availability of relatively easier gains through expansion of conventional inputs and technological change earlier enabled the decision-makers to shelve seriously addressing the policy inefficiencies and structural and institutional constraints on agricultural growth. However, with gains from the past sources of growth—expansion of irrigated land, new HYVs, and an intensified use of purchased inputs—nearly appropriated, productivity growth assumes a central role in meeting the challenges of the future. It is time to tackle forcefully the structural and institutional impediments that hamper the path to a sustained productivity performance in agriculture.

Appendix: Measurement and Data Issues

. The situation with regard to data availability in Pakistan is not entirely favorable and that is an important reason why productivity measurement has not yet become a active area of research. In a study of agricultural productivity, a decision has to be made at the outset whether to use the gross or net output (value-added) measure of productivity. The gross output series includes all of the final agricultural output of a sector; on the other hand, the value-added series measures the output produced by the inputs originating within the sector, i.e. the intermediate inputs are excluded. Some of the existing studies in Pakistan (Wizarat 1981, Khan 1994,1997) have used an output index based on value-added data—gross value-added (GVA) in million Rupees—while others have used a gross output index (Evenson and Rosegrant 1994).[12] In the Green revolution context of Pakistan, where technological change in agriculture came about with the introduction of HYVs and the associated use of complementary chemical inputs, the use of gross output index is more appropriate.[13]

The Tornqvist-Theil approximation to the Divisia Index (T-T) has been used for aggregation of outputs and inputs. The data on crops and wholesale and retail prices is available in the official documents. The major crops included are wheat, rice, cotton,

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[12] The gross value added (GVA) reported in official documents is obtained after subtracting intermediate purchased inputs from total gross value of output. On theoretical grounds, however, a value added series may not be an appropriate data series to work with because it implies existence of a value-added function, which in turn depends on the highly restrictive and unrealistic assumption of separability of intermediate inputs from primary inputs. Furthermore, even if the existence of the value-added function is presumed, the results obtained may be inaccurate and biased. The exclusion of intermediate inputs (seeds, fertilizers, pesticides etc.) would tend to attribute measured technical progress to capital and labor input, not leaving any room for enhanced efficiency in the use of purchased inputs.

[13] For use in the arithmetic index, the data series for gross value of output based on 1980-81 prices was obtained from the Report of the Sub-Committee on Sources of Growth, Committee on Economic and Social Well-Being for the Eighth Five Year Plan, May 1992 (Kemal and Islam 1992). As this latter data series only extended up-to 1992, it was brought up to the year 1996, with gross output data for major crops, minor crops and livestock reported in the Agricultural Statistics of Pakistan (ASP).

sugarcane, maize, bajra, jowar, barley, and gram. The minor crops included are mung, mash, masoor, potatoes and onions. The livestock sector in the output index is represented by milk, beef and mutton.[14] As farm-gate prices were not readily available, they were estimated from wholesale prices reported in the official documents by assuming that farm-gate prices were uniformly 20% lower than the wholesale prices.[15] In a few instances, wholesale prices were not available for some items and for some time periods. In these cases, farm-gate prices were obtained by assuming a 30% difference between retail and farm-gate prices.

The labor input used in productivity studies for developed countries is a flow variable in terms of hours of labor per period of time. However, in the developing countries where collection of data at national and sectoral levels is still at a fairly rudimentary stage, labor input is usually approximated by its stock during the time period in question i.e. the number of people employed in agriculture. As inaccuracies/biases are sure to enter into the analysis as a result of this approximation of a flow concept by a stock, in this study, the labor input series is measured as a flow variable i.e. the number of days worked by agricultural labor during the year.[16] Labor input is calculated by

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[14] These crops and livestock items cover about 71% of the value of gross product of agriculture (at current factor cost) in 1995-96. This coverage is greater for the major crops (88%) and livestock (74%) relative to minor crops. Only 13% of the minor crops could be covered due to non-availability of output and price data. However, it should be mentioned that the technological changes in agriculture appear to have affected the major crops and livestock more than the minor crops. Milk, beef and mutton quantities have not been reported for the period before 1970/71; therefore, they had to be extrapolated on the basis of per-capita consumption estimates, reported in national household surveys, and the size of the population.

[15] The Federal Bureau of Statistics (FBS) also uses this rule of thumb, when required. For example, as harvest prices for minor crops are generally not available, gross output in the minor crops sub-sector is calculated on the basis of prices that are assumed to be 80% of wholesale prices compiled by the Department of Agricultural marketing and Grading. (Fifty Years of Pakistan in Statistics, a FBS publication.)

[16] While Khan (1997) has assumed average working days per year to be 265, Evenson, Pray and Rosegrant (1999) in their recent productivity study of Indian agriculture have used average annual workdays of 244, 244 and 215 for Haryana, Punjab and Rajasthan states of India. As the agricultural conditions in these states are very similar to those found in Pakistan, in this study an average of 250 workdays in a year is used.

multiplying the number of agricultural laborers by the average annual workdays. Daily wage rates data have been obtained from various published sources.[17]

The land-input measure to be used in this study is the cultivated land area, which is calculated as a sum of net area sown and area left fallow that year. The service flow from land is measured in terms of annual rental value of a hectare of land in Rupees. Annual rental series have been obtained from Farm Management Surveys carried out by government agencies. These relate mainly to the irrigated area in the Punjab province, the largest province with the largest value-added contribution to agriculture in Pakistan.

The use of capital as an input into agricultural production has grown in importance overtime against a backdrop of land and labor scarcities in the agricultural economies of many countries, though it is not as fully utilized in underdeveloped countries as in the developed countries. Capital assets typically enter agricultural production by rendering productive services. Therefore, from the point of view of production/productivity measurement, estimation of the flow of services emanating from capital stocks is more important than the stocks themselves.

The measurement of capital input in Pakistan’s agriculture is also at a very elementary stage because of severe data constraints in this area. Wizarat (1981,1982) used a composite index of capital that included land rent, capital cost of private and public tube-wells, number of tractors and livestock. The PIDE macroeconometric model (1983), on the other hand, opts for even less sophistication by simply using the number of tractors as a proxy for capital and all other auxiliary inputs. Khan (1997), however, has

[17] For the years 1959/60 to 1965/66 data reported in Chaudhry and Chaudhry (1992) has been used; data for the years 1966/67 to 1982/83 are from ILO Yearbook of Labour Statistics; and the data for the years 1983/84 to 1992/93 has been obtained from the Pakistan Labour Gazette.

used tractors, tube-wells and work animals as the main capital inputs into Pakistan agriculture.[18]

In this study, the capital stock index includes tractors, tube-wells and working animals. The number of tractors data 1978-79 has been obtained from Wizarat (1981). The data for number of tractors imported -which also includes domestically manufactured tractors-has been collected from the Ministry of Finance, Economic Survey (statistical supplement, 1996-97). The perpetual inventory method was used to calculate the stock of tractors (numbers) (from 1966-67 onwards) after taking into account depreciation of the stock and the net annual addition by imports and domestic manufactures.[19] The rate of depreciation is assumed to be 10%, considering that a ten- year life span for a tractor is quite reasonable. The same procedure could not be followed for tube-wells as no reliable series for new tube-wells installed each year was available; so resort had to made to total number of tube-wells reported in the Agricultural Statistics of Pakistan. The data on working animals has also been taken from the Agricultural Statistics of Pakistan. Tractor prices and average costs of installation of a tube well have been collected from various official sources. The annual service flow from tractors and tube wells is assumed at 20 % of the value of the stock of these capital items. This includes the rate of depreciation (10

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[18] In the developing countries, the data pertaining to capital inputs are not as reliable and extensive as in developed countries. Dholakia and Dholakia (1993) in a study of TFP for Indian agriculture for the period1950-51 to 1988-89, measure capital stock in terms of net capital stock valued at 1980-81 prices. This capital stock measure includes agricultural machinery, farm equipment and tools, transport equipment in farm business, land improvements, investment in public and private irrigation, farm houses, and stock of inventories including livestock. Wen (1993), in his study of TFP of China's farm sector, uses an even simpler measure of capital input that includes only the values of draft animals, non-draft animals, poultry and farm machinery. Evenson et. al (1999) use bullocks and tractors as the primary sources of farm draught power in Indian agriculture.

[19] The capital stock at any one time represents the sum total of flow of accumulated investments over time after depreciation. The appropriate method for estimating the balance capital stock when it is being constantly replenished/augmented by new investments and at the same time being diminished by depreciation is Jorgenson's perpetual inventory method (Jorgenson, 1974).

%) and the opportunity cost/debt service of the investment.[20] For draught animals, this has been assumed at 15% of the annual price series, following Khan (1997).

Purchased intermediate inputs (fertilizers, pesticides etc.)—which between themselves largely embody the Green Revolution technology—cannot be ignored in any productivity study which includes the Green Revolution and the subsequent period.[21] As the use of these inputs has grown at a very fast rate in the post Green Revolution period with the rapid intensification of agriculture, studies that do not properly account for these inputs are not likely to arrive at reasonable estimates of TFP growth in agriculture.

In the present study, the fertilizer inputs are made up of the consumption (off-take) of the three main types of fertilizer nutrients, namely nitrogen, phosphates and potassium. The quantity in nutrient/ton is obtained from the Economic Survey. The price data reported in Pakistan Economic Survey consist of price per bag of 50 Kg. Given the known % nutrient content of each marketed compound, this information has been used to convert the price per 50 kg bag into price/nutrient ton of the relevant nutrient. For example:

P rice of Urea(46% N)/per 50 Kilo bag = Rs. x

Price of Urea(46% N)/ Metric Ton = Rs. 20x (Using 1000kg=1M.tonne)

Price of Nitrogen/ton = Rs 20x multiplied by 1/0.46

The effective price/nutrient ton was calculated by taking a weighted average of the prices of each nutrient calculated as above. Annual imports of pesticides in tons are reported in the official documents along with the value of the imports. The price/ton of imported

[20] Evenson et.al. (1999) use 25% of the tractor price series as the shadow rental cost of a tractor. This includes both depreciation and debt service on the investment.

pesticide can, therefore, be calculated from the value of import data. Assuming quantities to be imported are determined on the basis of anticipated usage, quantities imported serve as a proxy for quantities actually consumed.

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[21] Wizarat (1981) and Khan (1994) did not use any of the purchased inputs in constructing their input index as they used crop value-added as their output index. Khan (1997), however, includes only fertilizer as input.

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