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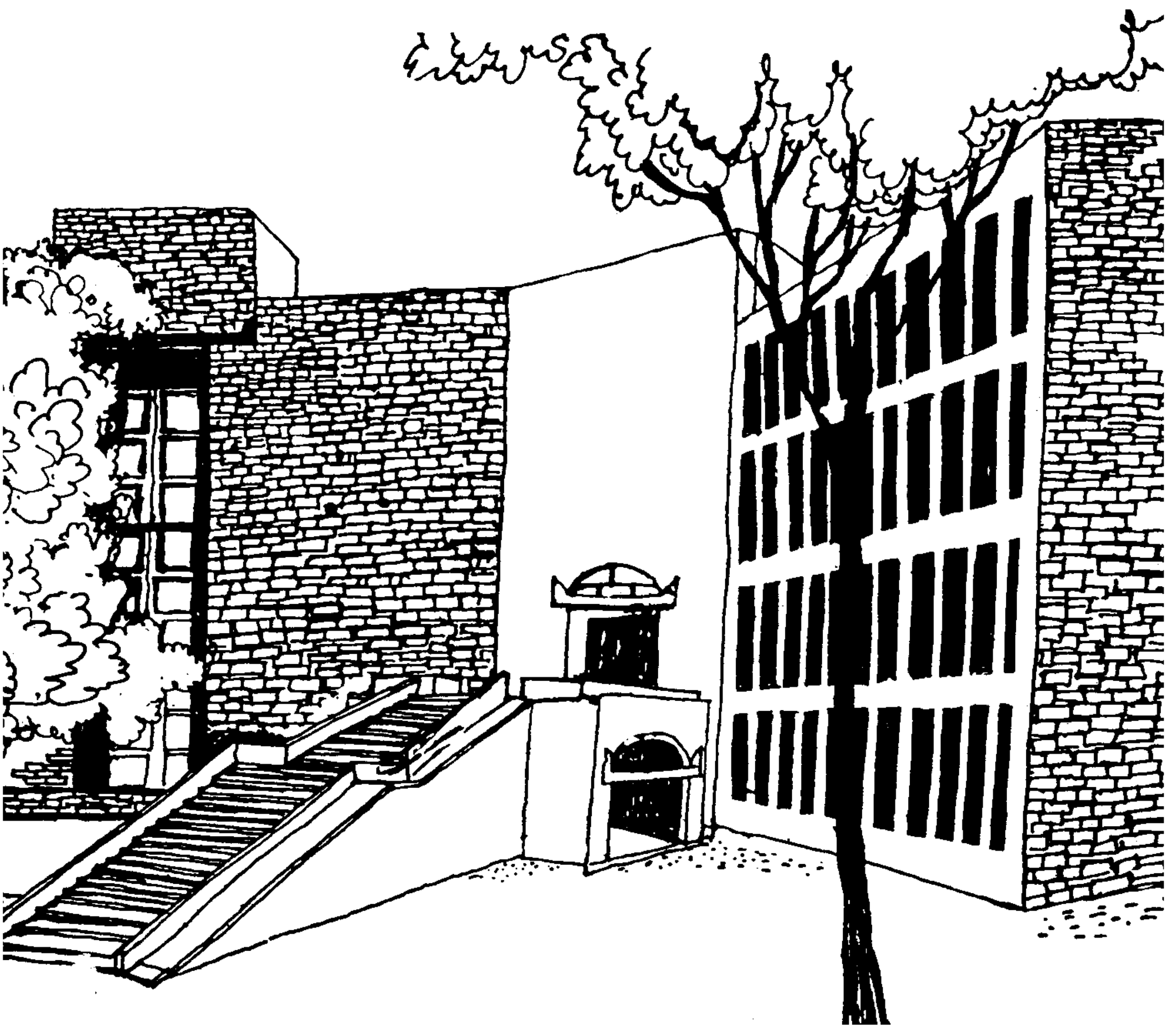

GROWTH OF TOTAL FACTOR PRODUCTIVITY IN INDIAN AGRICULTURE

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ABSTRACT

In the present study the sources of Growth of Indian agriculture have been estimated for three sub-periods during 1950-51 to 1988-89. It also estimates the contribution of adverse weather conditions and intensity of resource use to total factor productivity growth. It is found that TFPG has contributed significantly to the acceleration of agricultural growth facilitating release of scarce resources from agriculture to other sectors in the economy. Thus, TFPG in agriculture has been the prime driving force behind the acceleration of overall growth in the Indian economy achieved during the eighties. The main determinant of TFPG has been found to be the use of modern inputs like fertilizer, HYV seeds and irrigation. It is also argued that the government policies to encourage the use of modern inputs have played a critical role in achieving the acceleration of the agricultural and hence overall growth in the economy. The agricultural input subsidies, particularly fertilizer subsidy, have been the major policy instruments inducing modernisation of Indian agriculture.

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1. Introduction

By now, it is a well recognized fact that India experienced a marked upward shift in her long term growth rate during the eighties. There are differences of opinion on the exact point of the break in the time trend. In a recent study, Ganesh (1992) has applied the switching regression technique to the time series data on real GDP for the period 1950-51 to 1989-90 to conclusively establish that the most appropriate point of the break in the time trend in India is the year 1981-82. He also finds that while optimal point of break in the time trend of the secondary sector coincides with the one for the economy as a whole, the break of trend occurs in the primary sector in the preceding year (1980-81), and in the tertiary sector in the following year (1982-83). These findings only reiterate the primacy of agricultural sector in the growth process in India. To appreciate the role of agriculture in the acceleration of economic growth experienced recently in India, a detailed examination of the growth of agricultural sector is required. Agricultural sector can contribute to the acceleration in the national growth in two different ways : (a) by its own accelerated growth of output; and (b) by releasing scarce resources to the other sectors of the economy while maintaining its own growth. In order to examine these aspects, we have to consider the trends in total factor inputs and total factor productivity growth in the agricultural sector over time. In the present paper, we make an attempt to examine the sources of growth of Indian agriculture over its three distinct phases, viz. (a) the pre-green revolution period (1950-51 to 1966-67); (b) the initial phase of green revolution (1966-67 to 1980-81); and (c) modernisation phase (1980-81 onwards). The growth accounting framework popularised by Denison is used for the purpose. In the next section of the paper, we briefly discuss the concept and measurement of relevant variables and sources of data used in the study. The third section presents the findings on the main sources of growth of Indian agriculture. In the fourth section, the role of modern inputs in explaining the total factor productivity growth (TFPG) in Indian agriculture is discussed. The fifth section relates the main findings of the study to the policy issues currently debated. In the final section, summary and conclusions are presented.

2. Measurement of Variables and Sources of Data

2.1 *Total Factor Productivity* : Index of Total Factor Productivity measures the growth of net output per unit of total factor input. In the context of the methodology of growth accounting, which has been extensively used and refined by Denison (1967, 1985), total factor productivity growth is also termed as the residual factor because it represents that part of the growth of net output that is not accounted for by the growth of basic factor inputs such as land, labour and capital. In the production function framework, total factor productivity growth indicates technical progress which represents shifts in the production function over time. Thus, apart from improvements in techniques of production, advancement in knowledge and greater efficiency of the production system, betterment in the management practices, improvement in the quality of inputs, and increase in the degree of utilisation of resources are also included in the concept of technical progress defined in the production function framework. Basically, this is the concept of autonomous disembodied neutral technical progress as defined by Hicks (1963) and Harrod (1973). It is defined simply as the ability of the economy to obtain greater output from the given combination of inputs over a period of time. The same concept of technical progress is adopted in our study so that more meaningful assessment can be made of the role of technical progress in Indian agriculture in the overall economic growth and acceleration therein during the recent years. In the context of Indian agriculture, technical progress would measure the impact of shifts in production technology on account of irrigation, high yielding varieties of seeds, modern agricultural machinery and equipments, fertilizers, pesticides, etc. Moreover, it would also capture the effects of improved quality of labour, better farm management practices, greater utilization of resources like land and equipment which leads to increased crop intensity, changes in cropping pattern in favour of high value added crops, etc. The index of total factor productivity is derived as the ratio of the index of net output and the index of total factor input. The index of total factor input is derived as the weighted average of the indexes of labour input, capital input and land input with relative income shares of the three factors as the respective weights. Thus, to estimate total factor productivity growth in Indian agriculture, we need time-series data on net output, factor inputs, and relative factor shares in Indian agriculture.

2.2 *Scope of Agricultural Sector* : We have adopted a broad definition of agricultural sector to include not only the crop farming but also animal husbandry, plantations, orchards, fishery, forestry and logging. There are inseparable interlinks between the farm sector and these other sectors. Sometimes, their outputs are joint products in the sense that inputs used for their production are practically inseparable. Moreover, changes in the production environment in one generally affect the cruicial output decisions having implications on management of resources in other allied activities. All these considerations have governed our choice of selecting a broader definition of agricultural sector. Net output of the agricultural sector is measured in terms of net domestic product at 1980-81 prices. Currently, agriculture including animal husbandry accounts for 93% of the net output originating in the broadly defined agricualtural sector, while forestry contributes 4.6% and fishery contributes 2.4% of the total. Thus, farm sector overwhelmingly dominates the broadly defined agricultural sector in Indian economy.

2.3 *Factor Shares* : The Central Statistical Organization (CSO) used to provide until recently the estimates of factor incomes as a part of their national income estimates. From various issues of National Accounts Statistics brought out during the seventies and eighties, we have compiled time-series of factor incomes in agriculture covering the period from 1960-61 to 1983-84, which happens to be the latest year for each CSO estimates of factor incomes are available. One of the major problems with estimation of factor shares in Indian agriculture has been that the income of a large number of self-employed farmers represents a mixed income category that comprises of labour income as well as property income including rent, interest and profit. We have made an attempt to decompose this category of mixed income into the corresponding components of labour income and property income by assuming that the imputed value of average compensation for the labour of owner-cultivator is the same as the average compensation paid to agricultural labourers (including payments in cash and kind). Thus, from the CSO estimates of total compensation paid to agricultural labourers for the bench-mark years 1970-71 and 1980-81, we have derived average compensation per agricultural labourer and, by applying it to the corresponding estimate of total number of cultivators in the respective bench-mark years, we have obtained the estimated proportion of mixed income of self-employed farmers representing pure labour income for the bench-mark years 1970-71 and 1980-81. The required proportion for the bench-mark year 1960-61 is obtained from the study on India's sources of growth (Bakul Dholakia, 1974). The bench-mark estimates of the proportion of mixed income of farmers indicating pure labour income have been interpolated to derive year-wise estimates of this proportion for the period 1960-61 to 1983-84. Thus, the time-series of labour income in agriculture is obtained as total compensation paid to agricultural labourers plus imputed value of labour income of self-employed cultivators. Break-up of property income originating in agriculture (which represents the difference between NDP at current prices and the corresponding labour income) into factor income for land and factor income from capital is obtained by dividing total property income between land and capital in the same proportion as the current value of land used in agriculture and the corresponding current value of capital assets used in agriculture in a given year. The estimates of value of land and value of capital assets employed in agriculture are obtained from the Debt and Investment Surveys conducted by RBI for the bench-mark years 1961-62, 1971-72 and 1981-82.

2.4 *Labour Input*: Labour input is measured in terms of the usual status work force which is defined as the number of persons usually employed for a relatively longer period during the reference year. The annual estimates of work force employed in agricultural sector during the seventies and eighties are based on the data obtained from the quinquinnial employment surveys conducted by National Sample Survey Organization (NSSO). A recent NSSO publication (1990) provides a detailed summary of the comparative results of Worker Population Ratios (WPRs) for 27th round (1972-73), 32nd round (1977-78), 38th round (1983) and 43rd round (1987-88), classified by four categories of rural males, rural females, urban males and urban females and also their industry-wise distribution. From these bench-mark estimates, we have derived the time-series of sex-area specific WPRs covering the seventies and the eighties through appropriate category-wise interpolation. Sex-area specific WPRs for each year are then applied to the corresponding estimates of category-wise population to obtain the required time-series of working force in agriculture. The estimates for the fifties and the sixties are obtained from an earlier detailed study on India's Sources of Growth (Bakul Dholakia, 1974).

2.5 *Capital Input* : Capital input in agriculture is measured in terms of net capital stock valued at 1980-81 prices. Capital stock in agriculture includes agricultural machinery, farm equipment & tools, transport equipment used in farm business, land improvements, investment in public and private irrigation, farm houses, and stock of inventories including livestock. The time-series of net capital stock in agriculture has been derived from the official bench-mark estimates of net capital stock for March 1981 recently prepared by the CSO, and the CSO estimates of net capital formation in agriculture at 1980-81 prices covering the period 1950-51 to 1988-89. The methodology of estimation of net capital stock for the bench-mark year 1981 and also of net capital formation at 1980-81 prices has been discussed in detail in a recent CSO publication (CSO, 1989). It may be noted here that capital stock can be measured in terms of (a) real gross capital stock which represents cumulative undepreciated value of capital assets originally installed less the value of assets actually discarded, both valued at given base period prices, or (b) real net capital stock which represents cumulative depreciated value of capital assets at given base period prices. Use of the gross stock measure assumes that the usual wear and tear of assets taking place with the passage of time does not affect the effective supply of capital input; while the use of net stock measure implies that the effective supply of capital input is proportionately affected by such wear and tear which is conventionally measured in terms of the consumption of fixed capital. If reliable estimates of effective consumption of fixed capital (depreciation) indicating actual wear and tear of capital assets are available, the net stock measured based on such estimates represents a more accurate indicator of the effective supply of capital input. Following the recommendations of the Advisory Committee on National Accounts and also of the Working Group on Savings in early eighties, detailed studies have been carried out in CSO on the construction of life table of assets and estimation of consumption of fixed capital. As a result, the revised series of capital formation as well as the bench-mark estimates of net capital stock prepared by CSO are now based on fairly reliable estimates of consumption of fixed capital. For the present study, we have, therefore, used the time-series of net capital stock derived from the latest available CSO data to measure the growth of capital input in Indian agriculture.

2.6 *Land Input* : The land input in agriculture is measured in terms of net area sown. The time-series of net area sown covering the period 1950-51 to 1988-89 is derived from the information on land utilisation statistics and classification of area brought out by the Directorate of Economics and Statistics, Ministry of Agriculture.

2.7 *Weather* : The years affected by adverse weather conditions have been identified using the annual rainfall data. During the period 1950-51 to 1988-89, the specific years showing marked deficiency in rainfall were found to be : 1950-51, 1955-56, 1957-58, 1959-60, 1962-63, 1965-66, 1966-67, 1971-72, 1972-73, 1974-75, 1976-77, 1979-80, 1982-83, 1986-87 and 1987-88.

The time series of NDP in agricultural sector at 1980-81 prices, net capital stock at 1980-81 prices, working force and net area sown over the period 1950-51 to 1988-89 are presented in Appendix Table 1. Estimates of average relative factor shares in agricultural income are presented in Table 1.

3. Growth Accounting in Agriculture

According to the neo-classical framework for growth accounting, estimation of the sources of growth should be based on potential output growth rather than the actual or observed output growth. However, in most studies on the subject, this aspect is ignored by assuming that the growth of actual output is the same as that of the potential output. It is evident that in the case of agricultural sector this assumption would not hold. Potential output in agriculture under static conditions can be achieved when optimal factor combination is aided by favourable weather conditions. This is particularly important for countries like India where agriculture still remains heavily dependent on rainfall. Under the dynamic conditions, the potential output in agriculture represents the output which could be produced in the system under the best possible circumstances including the weather conditions. Thus, the concept of potential output can be operationalised by measuring it along the notional upper ridge of the time-series scatter. In order to obtain the estimate of the trend rate of growth of the potential output, the peaks lying on the upper ridge of the scatter are picked*[1] and a log-linear trend is fitted which turns out to be an excellent fit with an R-Square of 0.999. The estimated trend rate of growth of potential output is 2.19% per annum which is significant even at 0.1% level of significance. Moreover, in this case, there is no

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1 These years are : 1953-54, 1954-55, 1956-57, 1958-59, 1960-61, 1964-65, 1970-71, 1975-76, 1977-78, 1978-79, 1983-84 and 1988-89.

evidence of any shift in the trend occurring at any point over the period. Thus, the potential output in Indian agriculture throughout the period of 1950-51 to 1988-89 seems to be growing at the rate of 2.19% p.a.

Comparing this figure with the trend-rates given in Table-1, we find that over the whole period, the actual growth of agricultural income, whether corrected or not corrected for weather, turns out to be very similar though marginally lower. The phase-wise comparison is, however, revealing. In the pre-green revolution phase (1950-51 to 1966-67), the agricultural income growth was substantially less than the potential growth rate, whereas in the post-green revolution phase (1966-67 to 1980-81), it was significantly higher. Even within the latter phase, the initial phase of green revolution (1966-67 to 1980-81) had experienced only marginally higher growth of actual income as compared to the potential growth. It was only during the recent phase of modernisation (1980-81 to 1988-89) that the growth of actual income exceeded considerably the growth of potential income in Indian agriculture. Since the concept of potential output is based on the 'full' utilisation of the existing capacity which, in agriculture, is translated to the concept of 'full' utilisation of resources, it can be inferred from these observations that the degree of capacity utilisation (or resource-use) was actually declining during the pre-green revolution period even after we adjust for weather. During the initial phase of green revolution period, the degree of capacity

Table 1

Growth Rates of Income and Basic Factors and Factor Shares in Agricultural Sector

(In Per Cent)

Variables	1950-51 to 1966-67	1966-67 to 1980-81	1980-81 to 1988-89	1966-67 to 1988-89	1950-51 to 1988-89
(1)	(2)	(3)	(4)	(5)	(6)
			Actual Observed Trend Rates		
1. Income	1.87	2.24	2.42	2.31	2.12
	(7.53)	(6.17)	(4.33)	(13.63)	(30.31)
2. Labour	1.57	1.65	0.47	1.32	1.50
	(72.83)	(95.24)	(4.52)	(21.90)	(58.07)
3. Capital	2.22	3.23	2.21	3.04	2.77
	(64.73)	(63.75)	(35.03)	(59.24)	(74.87)
4. Land	0.88	0.15	0.09	0.12	0.37
	(11.46)	(1.95)	(0.86)	(3.60)	(10.50)
			Trend Rates Adjusted for Weather		
1. Income	1.99	2.24	2.77	2.31	2.13
	(9.52)	(8.10)	(8.16)	(19.40)	(39.89)
2. Labour	1.57	1.65	0.47	1.32	1.50
	(68.87)	(91.51)	(4.02)	(21.44)	(57.28)
3. Capital	2.21	3.23	2.20	3.04	2.76
	(68.95)	(61.52)	(31.50)	(58.11)	(73.87)
4. Land	0.90	0.15	0.13	0.12	0.37
	(11.69)	(2.51)	(1.13)	(4.44)	(10.55)
			Relative Factor Shares (in %)		
1. Labour	54.11	57 .47	59.32	58.16	56.48
2. Capital	11.83	11.94	13.66	12.59	12.27
3. Land	34.06	30.59	27.02	29.25	31.25

Note: 1. Growth rates are average annual rates obtained by fitting log-linear time trend assuming continuous compounding.

2. Figures in parantheses are t-values.

3. For concepts and sources of data, see the text, section 2.

utilisation (or resource-use) stabilised and thereafter it started rising rapidly over the recent phase of modernisation. Improvement in the resource-use or capacity utilisation constitutes a part of the total factor productivity growth (TFPG) in the conventional growth accounting framework. We, therefore, expect the TFPG to be much higher in the recent period as compared to the earlier phases. When we compare the TFPG across different phases of the agricultural growth, a separate estimate of the contribution of capacity utilisation would be very much useful.

Similarly, weather continues to be a critical factor affecting Indian agriculture. Deficient rainfall is largely the cause for the agricultural output dropping considerably in some years. Sometimes very sharp troughs change the average magnitude of the time-trend rate very significantly. The existence of such troughs on account of deficient rainfall or adverse weather conditions helps us to identify its contribution to the measured growth of TFP in agriculture. If we estimate the trend-rate with and without introducing the intercept weather dummy, the difference in the two rates provides an estimate of the contribution of adverse weather in the measured output growth in agriculture. Table 1 provides these estimates for different phases of agricultural growth in India. Adverse weather conditions contribute negatively during the pre-green revolution period and the modernisation phase. In the latter period its contribution in absolute terms was almost three times that in the earlier period. During the initial phase of green revolution, weather did not make much difference in the average observed growth rate of agriculture.

Accounting for the growth of agricultural incomes in India during different phases is done through the celebrated neo-classical growth equation modified to incorporate the capacity utilization and weather factor in the following way : (all aggregates for agricultural sector)

$$GYP = R_L.G_L + R_K.G_K + R_N.G_N + r \quad ----- \quad (1)$$

where GYP is growth rate of potential output, GL, GK and GN are growth rates of labour, capital and land, respectively; R_L, R_K and R_N are the relative shares of labour, capital and land, respectively, and r is the residual which represents an estimate of the rate of technical progress. Let GY be the actual or observed growth of output and GYW be the weather corrected growth of output, then,

$$r* = r + (GYW - GPY) + (GY - GYW) \quad -------- \quad (2)$$

where r* is the rate of measured/observed TFPG; (GYW - GPY) is the contribution of change in the degree of capacity utilisation; and (GY -GYW) is the contribution of adverse weather conditions to the TFPG.

When we consider equations (1) and (2) together, we get the main sources of growth of agricultural output because in equation (1) above, $R_L.G_L$, $R_K.G_K$ and $R_N.G_N$ represent the contributions of labour, capital and land respectively. Table 2 provides the estimates of the main sources of growth of agricultural income during different phases of agricultural development in India.

Table 2

Major Sources of Agricultural Income

(In Percentage Points)

Source	1950-51 to 1966-67	1966-67 to 1980-81	1980-81 to 1988-89	1966-67 to 1988-89	1950-51 to 1988-89
(1)	(2)	(3)	(4)	(5)	(6)
Labour	0.85	0.95	0.28	0.77	0.85
Capital	0.26	0.39	0.30	0.38	0.34
Land	0.30	0.05	0.02	0.04	0.12
TFI	1.41	1.39	0.60	1.19	1.31
TFPG (r*)	0.46	0.85	1.82	1.12	0.81
Changes in Capacity Utilisation	-0.20	0.05	0.58	0.12	-0.07
Adverse Weather Conditions	-0.12	0.00	-0.35	0.00	-0.01
Residual (r)	0.78	0.80	1.59	1.00	0.89
Actual Growth of Output (GY)	1.87	2.24	2.42	2.31	2.12
Growth of Potential Output (GYP)	2.19	2.19	2.19	2.19	2.19

Source : Table 1 above.

The Table provides important insights into the growth process in Indian agriculture. In the pre-green revolution period (1950-51 to 1966-67) the actual growth of output in agriculture was largely accounted for by the growth of factor inputs. Total factor inputs (TFI) accounted for 1.41% out of the observed growth of 1.87% p.a. during the period. The total factor productivity growth (TFPG or r*) contributed hardly 25% of the observed growth. Labour was the most dominant factor in the Indian agriculture during the pre-green revolution phase when growth of land was also making significant contribution. During the initial phase of green revolution (1966-67 to 1980-81), however, growth of land almost stopped. Labour still continued to be the most dominant contributor to the growth, but capital investments picked up and together with labour effectively substituted for the growth of land. Thus, during the initial phase of green revolution, the contribution of TFI did not drop in spite of the sharp decline in the contribution of land as compared to the pre-green revolution period. The major difference between the growth experience in the two phases lies in the contribution of TFPG which, in turn, led the actual growth of output in agriculture to accelerate from 1.87% p.a. to 2.24% p.a. The contribution of TFPG in absolute terms nearly doubled. In relative terms, it accounted for almost two-fifths of the observed growth.

The initial phase of green revolution is important in the history of Indian agriculture because it marked the halt of the declining trend in the degree of capacity utilisation in the sector. Table 2 clearly reveals that falling degree of capacity utilisation as well as adverse weather conditions were largely responsible for depressing the actual output growth of Indian agriculture in the pre-green revolution phase. Both these factors affect the actual output growth without affecting the contribution of basic factors to the growth. It is only TFPG which gets affected by these factors. If we adjust for these factors, we get a closer approximation to what may be termed losely as contribution of technical progress or the residual (r). As Table 2 reveals, the estimates of r in the pre-green revolution and initial phase of green revolution are not very different. The immediate contribution of the green revolution was to stop the declining trend in the degree of capacity utilization in agriculture and to augment the contributions of labour and capital in the agricultural growth. The higher rate of capital formation in the agricultural sector during the initial phase of green revolution was, thus, basically oriented towards building new capacity and increasing its utilisation.

The more recent phase of modernisation (1980-81 to 1988-89) in the Indian agriculture marks a clear departure from the past trend. This phase is different from the earlier phases not only because the actual growth of the agricultural sector is higher but also because the sources of agricultural growth and the growth processes implied thereby are considerably different. Land as a factor of production almost stagnated during this period. Capital investments also declined sharply compared to the initial phase of green revolution (1966-67 to 1980-81). What is most striking is that the growth of labour fell sharply during this period from 1.65% p.a. to only 0.47% p.a. (Table 1). Consequently, the contribution of labour to the agricultural growth significantly declined. In fact, contribution of all the three basic factors viz., land, labour and capital declined during 1980-81 to 1988-89 as compared to the previous period and yet the actual growth of agricultural output substantially increased during the period. Basically, this phenomenon points to the transformed character of agricultural sector with a fundamental change in the underlying growth processes. As Table 2 reveals, the contribution of total factor inputs (TFI) fell sharply from 1.4 percentage points to only 0.6 percentage points or from 62% to only 25% of the observed growth during this phase. This is a very important development because, for the first time since Independence, agricultural sector released resources for the growth and development of the other sectors in the economy during the period 1980 81 to 1988-89. The process of the release of resources from agricultural sector in this phase is important because it occurred simultaneously with the process of acceleration of output growth in the sector. It clearly shows that the efficiency of the resources as measured by the TFPG in the sector has been increasing.

The growth of total factor productivity in Indian agriculture contributed 75% of the observed growth during 1980-81 to 1988-89. In absolute terms also its contribution increased substantially, as revealed by Table 2, from only 0.85 percentage points in the previous period to 1.82 percentage points in this period. What is most significant is that during this period, the rate of capacity utilization considerably improved significantly contributing almost one-third of the TFPG. Had there not been the adverse weather conditions, the actual growth of output would have been 2.77% p.a. instead of the observed 2.42% p.a. during the modernisation phase. Thus, to a very large extent adverse weather conditions took away the gains from increased capacity utilization in Indian agriculture. However, the reason why we have preferred to call the period of the eighties as the modernisation phase of Indian agriculture is that the contribution of technical progress (residual) during this period has doubled in absolute terms as compared to the previous periods. In relative terms also its contribution in the growth of potential output (GYP) increased from 37% to 73%. Increasing growth of output, factor productivity and rate of capacity utilisation occurred in spite of declining growth rates of all basic factor inputs including capital during the eighties.

Whether the year 1980-81 marked a clear departure from the past trends in terms of the growth of total factor inputs (TFI) and growth of total factor productivity (TFP) can be statistically checked by fitting the time trends for both these variables. The indices of real NDP, the basic factors, TFI and TFP in the Indian agricultural sector over the period 1950-51 to

1988-89 are presented in Table 3. The test for the break in the trend of TFI and TFP indices at the point 1980-81 is carried out by fitting the Kinky log-lin trend lines [see Gujarati, 1988]. This test is equivalent to the one suggested by Boyce [1986] as shown by Ganesh [1991]. In the Kinky trend model, the sign of the coefficient of the dummy variable shows the increase (+ sign) or decrease (- sign) in the estimated trend rate after the Kink as compared to the one before the Kink. The results are summarised as under :

Dependent Variable (in Natural Log.)	Constant	Basic Trend Rate	Coefficient of Dummy	R-Square	F-Statistics
1. TFI	4.5884	0.0145	(-)0.0055	0.9990	17534.6
	(2447.10)	(148.40)	(10.46)		
2. TFP	4.6306	0.0061	0.0104	0.7768	62.64
	(273.87)	(6.88)	(2.19)		

[Figures in parantheses are t-values all of which are statistically significant at 5% level of significance.]

The results in both the cases are sharper with explanatory power (r-square) improving significantly when adjustments are made for weather conditions. The results clearly indicate a break in the trend-rates of indices of TFI and TFP in the year 1980-81 from which the growth in agricultural income shows acceleration. Thus, contribution of agricultural sector in the acceleration of overall growth of the Indian economy has been through both higher efficiency as indicated by the increased growth of TFP in agriculture as well as release of resources from agriculture to other sectors as revealed by the decreased growth of TFI in agri-

Table 3

Indices of Output, Basic Inputs and Total Factor Productivity and Relative Income Shares in Indian Agriculture, 1950-1989

Year	NDP Ind	K Ind	L-Ind	NSA-Ind	TFI Ind	TFP Ind
1950-51	100.00	100.00	100.00	100.00	100.00	100.00
1952	101.38	103.12	101.00	100.55	101.10	100.28
1953	104.52	105.81	102.16	103.95	103.20	101.28
1954	112.60	108.46	103.47	106.79	105.19	107.04
1955	115.57	110.82	104.92	107.66	106.55	108.47
1956	114.32	113.85	106.46	108.77	108.12	105.73
1957	120.49	116.68	108.13	110.19	109.84	109.70
1958	114.78	119.54	109.90	108.70	110.63	103.75
1959	126.58	122.05	111.77	111.01	112.73	112.29
1960	125.04	123.59	113.73	111.95	114.29	109.41
1961	133.50	126.27	115.74	112.17	115.77	115.31
1962	133.40	128.78	117.65	114.02	117.73	113.31
1963	130.46	131.63	119.57	114.81	119.38	109.28
1964	133.56	135.27	121.53	114.93	120.91	110.46
1965	145.90	138.84	123.52	116.31	122.88	118.73
1966	128.69	142.70	125.55	114.69	123.88	103.88
1967	126.41	146.38	127.61	115.56	125.73	100.54
1968	145.95	150.63	129.70	117.79	128.11	113.93
1969	145.41	155.06	131.82	115.63	129.19	112.56
1970	155.05	159.98	133.99	118.5356	131.39	118.01
1971	166.41	164.46	136.18	118.12	133.56	124.60
1972	162.78	169.22	138.42	117.66	135.28	120.33
1973	153.82	174.47	140.69	115.49	136.53	112.66
1974	165.08	179.98	143.23	119.93	140.00	117.91
1975	162.15	184.86	145.81	116.03	140.87	115.11
1976	183. 79	191.73	148.44	119.28	144.19	127.46
1977	172.23	199.94	151.11	117.46	146.13	117 .86

1978	189.95	206.66	153.83	119.54	149.13	127 .37
1979	193.94	213.25	155.79	120.40	151.29	128.19
1980	167.26	222.86	157.75	116.97	152.52	109.66
1981	188.81	230.37	159.74	117.90	154.85	121.93
1982	199.81	239.22	161.76	119.68	157.42	126.93
1983	195.94	243.89	163.79	118.58	159.20	123.08
1984	217.73	248.95	165.86	120.60	161.61	134.73
1985	217.40	255.09	166.16	118.65	162.00	134.20
1986	217.67	260.04	166.16	118.67	162.76	133.74
1987	213.49	265.18	166.29	118.02	163.35	130.69
1988	214.38	270.50	166.41	119.66	164.57	130.27
1989	246.57	275.72	166.54	120.34	165.52	148.97

Weights		Rl	RK	Rn
1950-51	1966-67	0.5411	0.1183	0.3406
1966-67	1980-81	0.5747	0.1194	0.3059
1980-81	1988-89	0.5932	0.1366	0.2702

culture during the eighties. Indian story of the acceleration in growth lends considerable support to the Ricardian hypothesis emphasising the primacy of the role of technical progress in agricultural sector in sustaining and accelerating the overall growth of the economy. In this context, it is interesting to examine the determinants of the growth of total factor productivity in Indian agriculture.

4. Determinants of TFPG in Agriculture

Since TFPG is considered a good proxy for the technical progress, if the latter is endogenous or induced, the variations in the TFPG would be significantly explained by capital, labour or capital per worker. In order to test the hypothesis about the induced versus exogenous technical progress in Indian agriculture, simple linear regression can be fitted with TFP index as the dependent variable and capital (K), labour (L) or capital per worker (K/L) as the independent variable. The results of such an exercise are reported in part (a) of Table 4. We have carried out the exercise for the period as a whole, i.e., 1950-51 to 1988-89 as well as for the post-green revolution period, i.e., 1966-67 to 1988-89. Moreover, we have also adjusted for the adverse weather conditions by explicitly considering the weather dummy for intercept. While all the estimates reported in part (a) of Table 4 are statistically highly significant, they call forth considerable caution for their interpretation in testing the abovestated hypothesis. This is because for each one of the regressions, the Durbin-Watson statistic is also highly significant suggesting clearly the existence of the positive autocorrelation which is likely to distort (by understating) the standard errors of the estimates.

Out of several remedial measures available, we have preferred the relatively simpler one of taking the first difference on both the sides and forcing the regression line through the origin. In the case of each regession in our case, the remedy is highly successful in correcting the problem of autocorrelation. The results are presented in part (b) of Table 4. While the results reported in part (b) of the table are

Table 4 : Results of Regression of TFP Index on Capital, Labour and Capital Intensity

Regression No.	Constant	K-Index	L-Index	K/L-Index	Weather Dummy	R-Square	Adjusted R-Square	D-W Static
1	2	3	4	5	6	7	8	9
	(a) Regression Coefficients with Levels of Variables							
I. For the Period : 1950-51 to 1988-89								
1)	88.602 (34.529)	0.1888* (13.215)	-	-	-7.1192* (-4.596)	0.8431*	0.8344*	1.258*
2)	62.250* (12.148)	-	0.4296* (11.534)	-	-7.1400* (-4.129)	0.8045*	0.7936	0.913*
3)	53.868* (10.701)	-	-	0.5479* (13.390)	-7.1878 (-4.691)	0.8465*	0.8379*	1.155*
II. For the Period : 1966-67 to 1988-89								
4)	87.009* (15.152)	0.1979* (7.209)	-	-	-8.5865* (-3.7963)	0.7696*	0.7457*	0.906*
5)	40.477* (14.029)	-	0.5725* (6.216)	-	-8.4314* (-2.885)	0.7172*	0.6889*	0.744*
6)	57.139* (9.415)	-	-	0.5776* (7.514)	-8.7149* (-3.972)	0.7131*	0.7614*	0.973*
	(b) Regression Coefficients with First Difference of Variables							
I. For the Period : 1950-51 to 1988-89								
7)	-	0.2096 (1.244)	-	-	-7.6905* (-7.412)	0.5989*	0.5878*	2.217
8)	-	-	0.4638 (1.084)	-	-7.6472* (-7.330)	0.5949*	0.5836*	2.264
9)	-	-	-	0.5073 (1.2019)	-7.7344* (-7.438)	0.5978*	0.5866*	2.246

(Contd..)

(Table 4 concluded)

Regression No.	Constant	K-Index	L-Index	K/L-Index	Weather Dummy	R-Square	Adjusted R-Square	D-W Statistic
1	2	3	4	5	6	7	8	9
II. For the Period : 1966-67 to 1988-89								
10)	-	0.2097 (0.178)	-	-	-9.6517* (-7.063)	0.6951*	0.6805*	1.845
11)	-	-	0.5510 (1.061)	-	-9.573* (-6.948)	0.6915*	0.6768*	1.755
12)	-	-	-	0.4730 (1.072)	-9.7067* (-7.067)	0.6918*	0.6772*	1.865

Note : (1) Figures in the Parantheses are t-values.
(2) *Statistically significant at 5% level.

similar in magnitude to those reported in part (a) of the table 4, they differ sharply in terms of statistical significance as revealed by the t-values of the estimates. In all the regressions reported in part (b) of the table, the weather dummy is the only significant variable explaining a part of the observed variation in TFP during the entire period of 1950-51 to 1988-89 and also over the post-green revolution period of 1966-67 to 1988-89. Capital, labour and capital per worker fail to provide statistically significant explanation and hence cannot be regarded as the determinants of the total factor productivity in Indian agriculture. Our results suggest that technical progress in the Indian agriculture may not be considered endogenous or induced particularly with reference to capital and labour.

Total factor productivity in agriculture is most likely to be governed by the application of modern agricultural inputs like increased use of irrigation facilities, fertilizers, high yielding varieties (HYV) of seeds, etc. These modern inputs improve the marginal productivity of the traditional factors - land, labour and capital. They also induce greater utilisation of these basic inputs which gets reflected in increased cropping intensity. We, therefore, postulate the following functional relationships:

TFP = f (CI, IRRI, FERT, HYV, D) ----------- (3)

CI = g (IRRI, FERT, HYV, D) ---------- (4)

where CI is cropping intensity measured as the ratio of gross to net area sown; IRRI is irrigation measured as the proportion of the gross area irrigated in gross area sown; FERT is fertilizer use measured as the fertilizer consumption per hectare of gross area sown; HYV is the high yielding varieties of seeds measured as the proportion of area under HYV in the gross area sown; and D is the intercept dummy for adverse weather conditions. All these variables except the dummy variable are considered in the form of indices.

Empirical estimation of these equations is likely to involve serious problems of multi-collinearity as well as autocorrelation since the estimation is based on the time series of highly interrelated variables. In our case, the presence of multi-collinearity is easily seen from the following:

Variable	Regressed on	R-Square
1) CI	IRRI; FERT; HYV	0.9575
2) IRRI	CI; FERT: HYV	0.9812
3) FERT	CI; IRRI; HYV	0.9667
4) HYV	CI; IRRI; FERT	0.9757

Such a high degree of correlations existing among these variables also indicates that they represent largely the same phenomenon. If we combine them to form one comprehensive variable, it should be possible to interpret such a variable as agricultural modernization index (AMI). In order to combine these variables into one, we may find the principal component of these variables. The first principal component of these variables explains about 98% of their total variation taken together irrespective of whether we consider the entire period of 1950-51 to 1988-89 or 1966-67 to 1988-89*[2]. The factor loadings in both the cases are as follows:

[2]. Since the proportion of area under HYV before the green revolution was negligible, the post-green revolution period is separately considered to capture the effect of modernization index on TFPG in agriculture more realistically.

Vriables[3]	1950-51 to 1988-89	1966-67 to 1988-89
CI	0.9773	0.9780
IRRI	0.9917	0.9911
FERT	0.9913	0.9826
HYV	0.9963	0.9913

Since the signs of all factor loadings are positive in both the periods, the first principal component can be easily interpreted as the agricultural modernization index (AMI). Using the AMI to replace its component factors in the equation (3) above, we get the following regression equation for testing our hypothesis :

$$TFP = a_0 + a_1 AMI + a_2 D + U \quad ------ (5)$$

Where a_i's are parameters and U is the random error with usual assumptions. The estimates based on the equation (5) for both the periods of time are presented below in Table 5. Again in this case, we find serious problems of interpretation of results arising out of the presence of positive auto-correlation when the levels of the variables are regressed. The probem of auto-correlation is resolved, however, when the first differences are regressed forcing the line through the origin. The estimates of the coefficients of the AMI and the weather dummy in both the periods are statistically significant and also similar in magni-

3. For principal component, the variables are transformed by normalizing any variable X into Z such that $Z_i = (X_i - \bar{X})/\sigma$. The factor loadings apply to such transformed variables to derive the principal component. It may also be recalled here that all our original variables are in terms of indices.

Table 5 : Results of Regression of TFP Index on Agricultural Modernization Index (AMI)

Period	Nature of Variables	Constant	AMI	Weather Dummy	R-Square	Adjusted R-Square	D-W Statistic
1	2	3	4	5	6	7	8
1) 1950-51 to 1988-89	Levels	80.062* (121.43)	0.1379* (12.763)	-4.4504* (-4.186)	0.8338*	0.8246*	0.976*
2) 1950-51 to 1988-89	First Difference	-	0.2136* (2.474)	-4.8495* (-7.316)	0.6418*	0.6319*	2.309
3) 1966-67 to 1988-89	Levels	84.625* (97.394)	0.1435* (8.060)	-5.3623* (-3.859)	0.8048*	0.7853*	0.910*
4) 1966-67 to 1988-89	First Difference	-	0.2152* (2.528)	-5.9185* (-6.903)	0.7544*	0.7421*	1.905

Note : (1) Figures in the Parantheses are t-values.
(2) *Statistically significant at 5% level.

tude between the two periods. Thus, the agricultural modernization index turns out to be a very important determinant of the total factor productivity in Indian agriculture. A one percentage point increase in the AMI would lead to about 0.21 percentage point increase in the TFP index in Indian agriculture.

As per equation (4) above, we have postulated that cropping intensity is determined by the use of modern inputs in agriculture and the weather. If it is so, the basic determinants of TFP in agriculture would be the use of modern agricultural inputs and weather. Again, in order to test this hypothosis, we have to resort to the principal component technique to avoid the problem of multi-collinearity. The first principal component of the three factors - IRRI, FERT and HYV, captures 99% of their total variance during the entire period of 1950-51 to 1988-89 and 98% of their total variance for the post-green revolution period of 1966-67 to 1988-89. The factor loadings in both the cases are as follows:

Variables	1950-51 to 1988-89	1966-67 to 1988-89
IRRI	0.9917	0.9911
FERT	0.9913	0.9826
HYV	0.9963	0.9913

Again signs of all the factor loadings are positive in both the periods. We may, therefore, interpret the principal component as the modern inputs index (MII). In order to test our hypothesis, therefore, we may consider the following two regression equations derived from equations (3) and (4):

$$TFP = b_0 + b_1 MII + b_2 D + U^1 \quad \text{------------} \quad (6)$$

$$CI = C_0 + C_1 MII + C_2 D + U'' \quad \text{------------} \quad (7)$$

Where b_i's and C_i's are parameters and U' and U" are random error terms. The estimates of these equations are made for both the periods. Table 6 and Table 7 present the estimates based on equations (6) and (7), respectively.

Again, the estimation based on first differences forcing the regression line through the origin resolves the problem of autocorrelation in the case of equation (6). The results reported in Table 6 clearly support our hypothesis that the use

Table 6 : Results of Regression of TFP Index on Modern Input Index (MII) in Agricultural Sector

Period	Nature of Variables	Constant	MII	Weather Dummy	R-Square	Adjusted R-Square	D-W Static
1	2	3	4	5	6	7	8
1) 1950-51 to 1988-89	Levels	80.064* (121.290)	0.1383* (12.475)	-4.4538* (-4.184)	0.8334*	0.8242*	0.976*
2) 1950-51 to 1988-89	First Difference	-	0.2118* (2.451)	-4.8611* (-7.331)	0.6415*	0.6315*	2.311
3) 1966-67 to 1988-89	Levels	84.627* (97.416)	0.1440* (8.062)	-5.3670* (-3.8625)	0.8049*	0.7854*	0.911*
4) 1966-67 to 1988-89	First Difference	-	0.2153* (2.537)	-5.917* (-6.906)	0.7548*	0.7426*	1.910

Note : (1) Figures in the Parantheses are t-values.
(2) *Statistically significant at 5% level.

Table 7 : Results of Regression of Cropping Intensity Index on Modern Input Index (MII)

Period	Nature of Variables	Constant	MII	Weather Dummy	R-Square	Adjusted R-Square	D-W Static
1	2	3	4	5	6	7	8
1) 1966-68 to 1988-89	Levels	1.1867* (481.15)	0.0009* (22.351)	-0.0057 (-1.7303)	0.9620*	0.9582*	2.069
2) 1950-51 to 1988-89	Levels	1.1842* (554.94)	0.0010* (28.004)	-0.0040 (-1.1725)	0.9562*	0.9538*	0.9256*
3) 1950-51 to 1988-89	**	1.1840* (379.64)	0.0010* (16.176)	-0.0063 (-2.6368)	0.9562*	0.9538*	1.8286

Note : (1) Figures in the Parantheses are t-values.
(2) *Statistically significant at 5% level.

** Regression was run by transforming variables on the basis of procedure and deriving the original coefficient. The R-squares are, therefore, based on original variables and not transformed variables. Similarly, the D-W statistic in this case also cannot be used to reject the null hypothesis of no auto- correlation. Alternatively, the 'runs test' was used to accept the hypothesis of no autocorrelation. [see, Gujarati, 1988].

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of modern agricultural inputs determines the total factor productivity corrected for weather. Interestingly the estimates of the coefficient of MII are very similar in magnitude not only in the two periods but also to the ones of AMI in Table 5. Thus, as per our estimates, the TFP index would increase by 0.21 percentages points when the modern agricultural input index increases by one percentage point. Since the factor loadings forthe MII suggests more or lessequal weightage to the three component factors, a unit increase in each of the indices of the three variables, viz., IRRI, FERT and HYV, would contribute to the TFP index in the inverse porportion of their standard deviations.

Results reported in Table 7 again corroborate our hypothesis about the use of modern agricultural inputs positively determining the cropping intensity and thereby the rate of resource utilization in agricultural sector. For the post-green revolution period, the equation (7) fits well without any major estimation problem. However, when we consider the period as a whole, (1950-51 to 1988-89), the problem of autocorrelation arises which does not get resolved by the simple technique of first differences. The Cochrane-Orcutt iterative procedure is, therefore, employed to get the estimates. Again, the estimates of the coefficients of the MII for the two periods turn out to be remarkably similar which enhances our confidence in the results.

To summarise our findings in this section, we may emphasise the role of modernisation process of agriculture in determining the total factor productivity growth or the rate of technical progress in agriculture. It is also found that the use of modern inputs in the Indian agriculture has been mainly responsible for stepping up the rate of resource utilisation and hence in accelerating TFPG in agricultural sector.

V. Policy Issues

In the present paper we have shown that the role of growth in agricultural sector is very crucial in the Indian growth experience. The acceleration of the overall growth of the eighties began with acceleration of agricultural growth in 1980-81. The main factor accounting for acceleration in the Indian agricultural growth was the growth of total factor productivity which represents the technical progress in agriculture. The latter is governed by the intensity of resource utilisation and the use of modern agricultural inputs besides weather. Thus, the major explanation for the whole process of growth acceleration of the eighties in the Indian economy centres around the increased use of modern agricultural inputs. Whether the government policies played any deterministic role in increasing the use of the modern inputs in agriculture is a subject of separate research which has not been fully investigated in the literature on the subject. In this concluding part of our study, we have made an attempt to examine the main issues involved in altering the policy interventions already in vogue for a long time in regard to the modern agricultural inputs.

In the case of irrigation, the use can be increased in two ways : (a) by providing greater irrigation facilities; and (b) by ensuring greater utilisation rate of the potential already created. While there exist limits on both these fronts, in the present Indian situation, considerable scope still exists on both the counts to increase the irrigation use. The government policies to encourage the irrigation water use in the Indian agriculture concentrated largely on providing the surface irrigation in the form of canal water from the major, medium and minor irrigation projects at subsidised rates. The other route of irrigation related subsidies is through special schemes of subsidies for well construction, energising existing wells, providing credit for such purposes at concessional rates, etc. Although there is a controversy about the magnitude of irrigation subsidies, their existence is well accepted in the literature [see for instance Gulati, 1989 and Acharya, 1992]. As per Acharya's [1992] findings, the irrigation subsidy*[4] is overwhelmingly important among all input subsidies in all the

4. It may be noted that Acharya [1992] also uses Gulati's [1989] estimates of the irrigation subsidy which is based on a notion of the rate of return on the capital cost of major and medium irrigation projects only. However, when we add the electricity subsidy which largely considers minor irrigation, the total of the two can be treated as a reasonably good approximation of the total irrigation subsidy.

major Indian states except Uttar Pradesh and Himachal Pradesh. According to his estimates, the returns per hectare would fall by more than one-third in states like Andhra Pradesh, Haryana, Punjab and Orissa if the irrigation subsidy is withdrawn. These estimates, however, do not include the effects of the withdrawal of the subsidies on the irrigation use. It is rather unfortunate that rigorous estimates of the price elasticity of demand for irrigation are not available for the Indian agriculture. Acharya's [1992] findings, however, indicate that irrigation subsidy is a substantial component of the net returns to the Indian farmers and hence its withdrawal or reduction is likely to affect their supply response and hence growth of agricultural production adversely.

The government policies concerning the rate of utilisation of existing irrigation facilities are less aggressive and more pursuasive in nature. The policies mainly consist of extension projects and schemes such as demonstration plots in newly irrigated areas. The pricing of irrigation - particularly the canal irrigation - is still based on crop and area rather than volume of water used. This not only leads to wastage of the irrigation water but may also prove harmful to the land productivity in the long run. Improved water management practices and consistent pricing policies under such circumstances have a great potential to influence irrigation utilisation rate favourably. Successful formulation and implementation of such policies, therefore, hold the key to sustain accelerated pace of agricultural growth in India during the nineties and beyond.

Application of the high yielding varieties of seeds is again an important modern input raising the total factor productivity in agriculture. The main component of government policies in this regard consists of promoting agricultural research stations and research institutions to develop agro-climatically most suitable HYV seeds. The other policies to encourage the use of HYVs include subsidy on seeds, distribution network to make them available on time and in required quantity, and extension schemes like agricultural demonstration plots. The latter are hardly found satisfactorily working on account of several problems pertaining to their design, management of the delivery system, lack of coordination with other schemes, etc. [see, for instance, Dholakia and Iyengar, 1988]. There is a good scope for making these policies more effective so as to improve the use of HYV seeds in Indian agriculture. Since seeds constitute a very small proportion of the total cost of production in the case of most of the major crops, the seed-price elasticity of profits in these crops has been found to be extremely low [see Acharya, 1992]. Subsidizing the price of HYV seeds is, therefore, not likely to invoke any substantial response in the use of such seeds by the farmers. The government policies have to concentrate on non-price factors for enhancing the use of HYV seeds.

Fertilizer use is another important modern input determining the total factor productivity in agriculture. Since India has still not become self-sufficient in fertilizer, government policies in this regard are very crucial. Fertilizer policy will have far reaching implications not only in terms of the profitability of the crops but also on prices of basic food articles, prices of raw materials consumed by agro-based indistries and the country's balance of payments. Acharya [1992] finds that the direct effect of the total withdrawal of fertilizer subsidy on the returns per hectare in different states varies considerably from as low as only 0.35% in Assam to 7.33% in Punjab. Although these estimates suggest relatively small magnitude of influence of the fertilizer subsidies, they could be highly misleading because these estimates consider only the direct effects of reduced subsidies and actually ignore the indirect effects on the returns arising out of the reduced use of fertilizer in response to its higher prices. The price elasticity of demand for fertilizer is a critical estimate in the whole argument. The latest empirical evidence for the Indian agriculture suggests that the price elasticity of demand for fertilizer is in the range of (-)1.3 to (-)1.5 [see, Kundu and Vashist, 1991; and Subramaniyan and Nirmala; 1991]. Accordingly, if the ratio of price of fertilizer to the price of agricultural commodity rises by 1%, the consumption of fertilizer per hectare would fall by 1.3% to 1.5%, other things remaining the same. If the fertilizer subsidy were to be totally withdrawn, it may raise the fertilizer prices in absolute terms by 30%. Assuming that farmers maintain their returns, the prices of agricultural commodities may consequently go up by 3% to 4%. Thus, total withdrawal of fertilizer subsidy may lead to about 25% rise in the relative price of fertilizers, which would lead to 35% fall in the demand for fertilizer per hectare, other things remaining the same. Our findings in the prsent study indicate that such a decline in the consumption of fertilizer per hectare may lead to a decline of 0.31 percentage point in the TFPG. It can be seen from Table 2 above that all the acceleration in the growth of agricultural sector achieved during the eighties in India would be totally neutralized by such a sharp decline in the TFPG.

The empirical exercise of the present paper suggests that the government policies of subsidising modern agricultural inputs - particularly fertilizer - to encourage their usage are most likely to have caused acceleration in the Indian agricultural growth after 1980-81 by achieving sharp increases in the total factor productivity in the sector. It has also helped release valuable scarce resources for rapid growth of the industry and service sectors in the economy ultimately leading it to break-off from the 'Hindu Rate of Growth' path during the eighties. If such input subsidies have to be stopped on account of IMF conditionalities on the ground that they constitute 'unproductive' and 'unplanned' revenue expenditures of the government, the economic consequencs of such steps are likely to be serious in terms of (i) growth of agricultural sector losing its recently achieved acceleration; (ii) prices of food and other agricultural products rising sharply; (iii) imports of food and agricultural products being imperative to avoid food scarcity; and (iv) overall slowing down of the pace of growth in the economy. It is high time that such growth oriented pricing policies are considered 'productive' and 'planned' investments rather than 'unproductive and unplanned' expenditures especially in the case of developing economies.

VI. Summary and Conclusions

In the present paper, we have estimated sources of growth of Indian agriculture over three sub-periods : (i) pre-green revolution phase (1950-51 to 1966-67); (ii) initial phase of green revolution (1966-67 to 1980-81); and (iii) modernisation phase (1980-81 to 1988-89). It is found that TFPG has contributed significantly to the acceleration of agricultural growth facilitating release of scarce resources from agriculture to other sectors in the economy. Thus, TFPG in agriculture has been the prime driving force behind the acceleration of overall growth in the Indian economy achieved during the eighties. Technical progress in the Indian agriculture as measured through TFPG has not been found to be directly determined by capital, labour or capital per worker. The main determinant of TFPG has been found to be the use of modern inputs in the Indian agriculture. The modern inputs like HYV seeds, fertilizer and irrigation have successfully raised the TFPG in Indian agriculture particularly during the eighties. It is also argued that the government policies to encourge the use of modern inputs seem to have played a critical role in achieving the acceleration of the agricultural and hence overall growth in the economy. The agricultural input subsidies, particularly fertilizer subsidy, have been the major policy instruments inducing modernisation of Indian agriculture. The estimates presented here indicate that complete withdrawal of fertilizer subsidy alone could wipe out the entire acceleration in the growth of agricultural output achieved during the eighties. Hence, if the tempo of accelerated growth of Indian agriculture has to be maintained during the nineties, there is a case for continuation of subsidies on modern agricultural inputs.

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Appendix Table 1

Time-Series of Net Output and Factor Inputs in Indian Agriculture

Year	Net Domestic Product (Rs. Crore at 1980-81 Prices)	Net Capital Stock (Rs. Crore at 1980-81 Prices)	Working Force (Million Nos.)	Net Area Sown (Million Ha.)
1950-51	23,262	31,217	124.28	118.75
1951-52	23,584	32,192	125.53	119.40
1952-53	24,314	33,030	126.97	123.44
1953-54	26,194	33,859	128.59	126.81
1954-55	26,884	34,596	130.39	127.85
1955-56	26,592	35,540	132.31	129.16
1956-57	28,029	36,425	134.38	130.85
1957-58	26,700	37,316	136.58	129.08
1958-59	29,446	38,582	141.34	132.94
1959-60	29,086	38,582	141.34	132.94
1960-61	31,054	39,418	143.84	133.20
1961-62	31,032	40,201	146.21	135.40
1962-63	30,348	41,092	148.60	136.34
1963-64	31,068	42,228	151.04	136.48
1964-65	33,940	43,343	153.51	138.12
1965-66	29,936	44,547	156.03	136.20
1966-67	29,406	45,696	158.59	137.23
1967-68	33,951	47,022	161.19	139.88
1968-69	33,825	48,404	163.83	137.31
1969-70	36,068	49,941	166.52	138.77
1970-71	38,711	51,338	169.25	140.27
1971-72	37,867	52,824	172.03	139.72
1972-73	35,782	54,463	174.85	137.14
1973-74	38,400	56,183	178.01	142.42

1974-75	37,720	57,708	181.21	137.79
1975-76	42,753	59,851	184.48	141.65
1976-77	40,064	62,416	187.80	139.48
1977-78	44,186	64,514	191.18	141.95
1978-79	45,115	66,571	193.61	142.98
1979-80	38,908	69,570	196.05	138.90
1980-81	43,921	71,915	198.52	140.01
1981-82	46,480	74,054	201.03	142.12
1982-83	45,579	76,135	203.56	140.81
1983-84	50,648	77,715	206.13	143.21
1984-85	50,571	79,632	206.32	140.90
1985-86	50,635	81,176	206.50	140.92
1986-87	49,662	82,780	206.67	140.15
1987-88	49,870	84,443	206.82	142.10
1988-89	57,357	86,070	206.97	142.90

Source: See the text, Section 2.

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