Structural Change in Composition of Foodgrains Production

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This paper examines structural changes in the composition of foodgrains production since 1965 and the role of movements in relative prices in bringing about these changes. Section I of the paper discusses briefly the methodology and data used and Section II presents the empirical results of the exercise, while Section III makes some concluding observations in the light of the results obtained in Section II.

THERE are some propositions in our empirical literature regarding the performance of foodgrains production in Indian agriculture:

(i) The new agricultural technology introduced in India in 1965 has resulted in a spectacular increase in the growth of output of certain superior food crops (such as wheat, rice, etc), whereas the growth of output of some inferior food crops (such as bajra, jowar, gram, etc) have declined.

(ii) Among the superior food crops, breakthroughs in production conditions have taken place only in the case of wheat.

(iii) Increase in the relative price of wheat resulted in the increase in its production.

(iv) Imbalances in the cropping pattern over time are mainly due to changes in relative prices of different crops.

We have posed the problem in terms of certain propositions for the reason that we find hardly any empirical literature which has examined the issues in detail. This paper attempts to examine some of the above propositions in terms of some time series data available in our official statistics. We have presented our discussion in three sections. Section I discusses briefly the methodology and data used in this analysis. Section II presents the empirical results of the exercise. Section III makes some concluding observations in the light of the results obtained in Section II.

I
Methodology and Data

The fitting of trend curves—simultaneously considering three types of fits, viz, semi-logarithmic, straight line and Gompertz or considering any one or two of these three fits—to agricultural produce or cropwise agricultural output was the basis of analysis of the earlier works.[1] They used the same set of data, but obtained different results regarding the nature of the trend rate of growth of agricultural production. Thus no definite conclusion regarding the performance of Indian agriculture in a time perspective has been achieved.

The reason lies in the fact that even if the data are presentable by a particular mathematical curve $f_1(t) = AB^t$, there would always be other functions $f_2(t) = mt + c$, $f_3(t) = ab^c$ etc, which might give comparatively good fits. However, different curves have different implications regarding the nature of the trend rate of growth. Thus two different fitted curves could be more or less same from the point of view of the goodness of fit, but might imply a completely different nature of the trend rate of growth. This is what seems to be true with most, if not all, of the studies in the Indian context.[2]

In view of such difficulties associated with the estimation of growth rates in Indian agriculture, we would like to avoid the fitting of different trend curves in our present analysis, but examine the change in foodgrains production on the basis of a simple statistical method which is described below.

We have plotted the data on foodgrains production in a scattar diagram and located the break, if any, in the time trend. We find that at the all-India level, there has indeed been a break taking place in foodgrains production in the year 1967-68, i e, at the beginning of the so-called green revolution period.

Thus two separate estimates of the time trends can be obtained for the two periods, i e, before and after 1967-68. Both the periods allow us to choose the linear form of the type $y = a + bt$, with the time series data. We have fitted a regression of the type described above for the two periods separately and estimates of trend growth ratio for each period to be found from coefficient b.

Another interesting point we would like to make here is about the nature of data that have been used by the earlier authors for this kind of analysis. Most of the authors have need physical units of production for trend

TABLE 1: ESTIMATED LINEAR TREND EQUATIONS FOR PRODUCTION OF MAJOR FOOD CROPS DURING 1950-51 TO 1967-68

Crops Compared	Estimated Parameters of Linear Trend Equation				
	Intercept	SE of Intercept	Slope	SE of Slope	R^2
(1)	(2)	(3)	(4)	(5)	(6)
(1) Ratio of rice to total cereals	61.7635*	1.1839	0.0060	0.1005	0.0002
(2) Ratio of wheat to total cereals	12.8662*	0.3253	0.1492*	0.0529	0.3339
(3) Ratio of wheat to rice	20.2271*	1.6054	0.2930**	0.1171	0.2814
(4) Ratio of wheat to other cereals	48.6083*	7.3759	1.1231*	0.2510	0.5560
(5) Ratio of rice to other cereals	2.4181*	0.0169	0.0183	0.0120	0.1270
(6) Ratio of cereals to total agricultural output	41.8261*	0.5591	0.1975*	0.0693	0.3381

Notes: * Indicates significant at 1 per cent level of probability.
** Indicates significant at 5 per cent level of probability.

TABLE 2: ESTIMATED LINEAR TREND EQUATIONS FOR PRODUCTION OF MAJOR FOOD CROPS DURING 1968-69 TO 1984-85

Crops Compared	Estimated Parameters of Linear Trend Equation				
	Intercept	SE of Intercept	Slope	SE of Slope	R^2
(1)	(2)	(3)	(4)	(5)	(6)
(1) Ratio of rice to total cereals	58.9662*	0.6940	0.3488*	0.0812	0.5510
(2) Ratio of wheat to total cereals	20.0595*	0.6883	0.6159*	0.0812	0.7941
(3) Ratio of wheat to rice	33.5575*	4.5521	1.3980*	0.2083	0.7503
(4) Ratio of wheat to other cereals	92.0259**	52.5868	5.3963*	0.7077	0.7949
(5) Ratio of rice to other cereals	2.8107*	0.0132	0.0245**	0.0112	0.2416
(6) Ratio of cereals to total agricultural production	46.1458*	0.3983	0.2192*	0.0616	0.4578

Notes: * Indicates significant at 1 per cent level of probability.
** Indicates significant at 5 per cent level of probability.

analysis and have been sceptical about using output measured in terms of value units. The usual argument in defence of such a practice has been that, unlike the manufacturing sector, agricultural products are more homogeneous in nature and therefore the estimation of growth rates on the basis of physical units makes much more sense for the purpose of comparison. The argument of homogeneity seems, however, not to be very strong from the point of view of importance of the crops to the fulfilment of basic requirements of various classes of people. As a matter of fact, the importance of various agricultural commodities differs across various classes of people in various regions with different food habits. It would, therefore, be fallacious to give similar weightage for each group of crops (e g, foodgrains, etc) even for the various crops under foodgrains for all the regions. For this purpose an appropriate weighting scheme should be evolved by considering the relative importance of different crops to the different classes of people in various regions. In the absence of such a methodology, this problem could be overcome if one chooses value figures of output of various crops. Here prices act as weights and one need not give weights across regions or classes which are, however, necessary in the construction of a physical index. We have, thus, compiled two sets of data: (i) value of cereals produced at an all-India level during 1950-51 to 1984-85; and (ii) value of output for all agricultural commodities at an all-India level during 1950-51 to 1984-85. The value figures have been taken at constant (1970-71) prices and are available in *National Accounts Statistics*. To explain the trend results obtained in our study we have used some other data, viz, index number of wholesale prices of different food commodities, value of agricultural inputs at constant prices, etc, collated from *Reserve Bank of India Bulletins, National Accounts Statistics*, etc. We shall now present some results of our analysis in the following section.

II
Results

Presented in Tables 1 and 2 are the results of estimated linear trend equations for the time-series on output of major food crops in India over the periods 1950-51 to 1967-68 and 1968-69 to 1984-85, respectively. Trends in the composition of cereals production for the period 1950-51 to 1967-68 show that the pattern of change in the share of wheat in total cereals production is statistically significant whereas the share of rice in total cereals production is insignificant (Table 1). As far as the latter period is concerned (i e, the period beginning 1968-69), a significant declining trend is observed in the share of rice in total cereals production and the opposite is true in the case of the share of wheat in total cereals production. Tables 1 and 2 further show that the time trends of the ratios of wheat to rice production for

DIAGRAM 1: SHOWING OBSERVED AND ESTIMATED TIME TRENDS OF AGRICULTURAL PRODUCTION

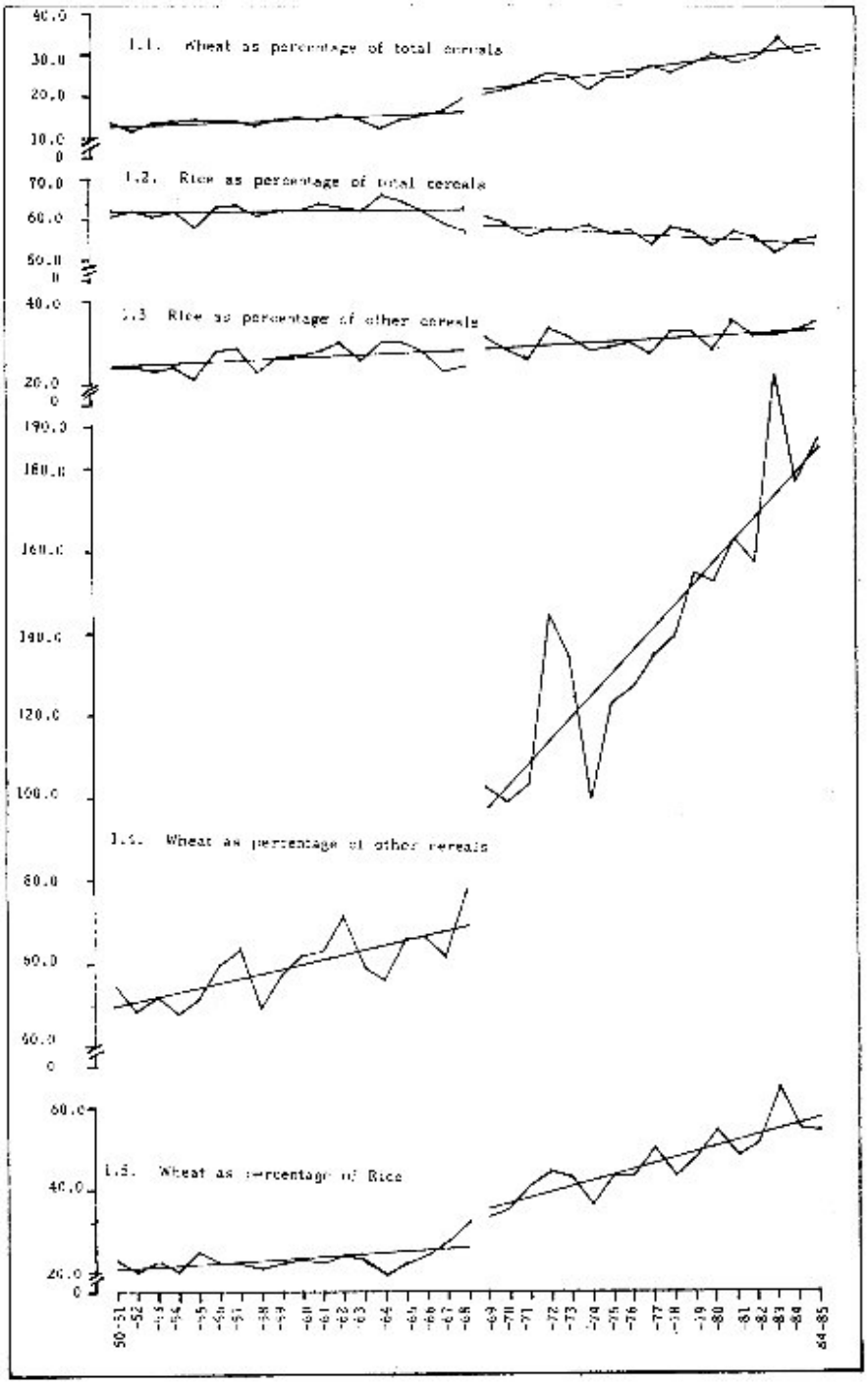


TABLE 3: ESTIMATED LINEAR TREND EQUATIONS FOR RELATIVE PRICES OF MAJOR FOOD CROPS DURING 1952-53 TO 1967-68

Crops Compared	Estimated Parameters of Linear Trend Equation				
	Intercept	SE of Intercept	Slope	SE of Slope	R^2
(1)	(2)	(3)	(4)	(5)	(6)
(1) Ratio of rice to total cereals	1.0002*	0.0002	−0.0009	0.0016	0.0222
(2) Ratio of wheat to total cereals	1.0234*	0.0005	−0.0054**	0.0023	0.2792
(3) Ratio of rice to wheat	0.9814*	0.0015	0.0044	0.0040	0.0807
(4) All cereals	31.7700	30.7609	3.0050*	0.5736	0.6622

Notes: * Indicates significant at 1 per cent level of probability.
** Indicates significant at 5 per cent level of probability.

these two periods are statistically significant and the value of coefficient of multiple determination (R^2) is high for the latter period only. The same picture is obtained regarding the pattern of change in the share of wheat production to the production of other cereals. Time trends of the ratios of rice to other cereals production, however, do not indicate any significant change between these two periods.

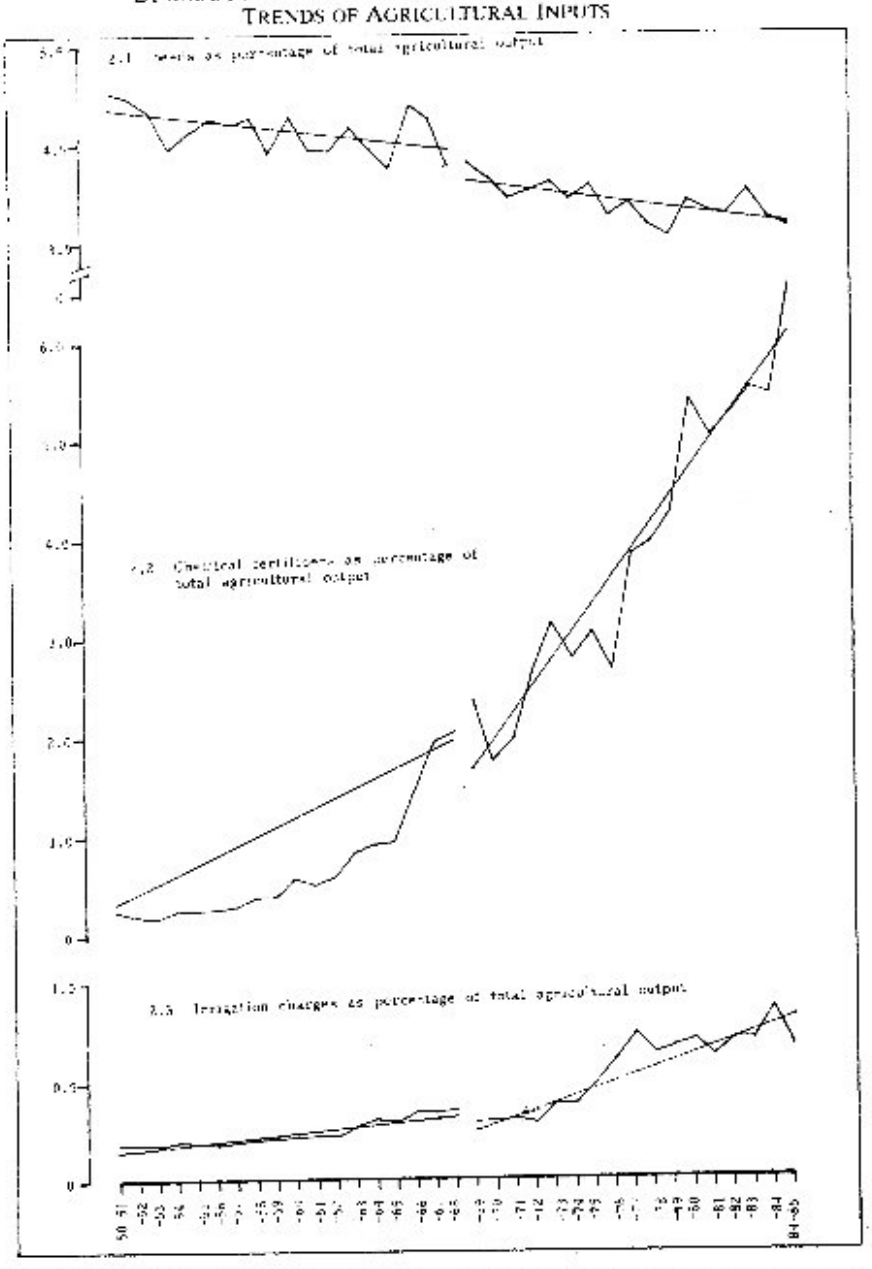
We have plotted the observed and estimated trend results of production of cereal crops. Diagram 1 shows clearly the structural break in the trend in wheat production, sharp decline in the production of other cereals and mild decline in the production of rice during 1950-51 to 1984-85. Sharp increase in the production of wheat with respect to both rice and other cereals is clearly observed from the diagram.

How one can explain the observed patterns of time trends in the composition of cereals production? A number of factors might be responsible for changing the composition of cereals production over time, viz, differential rate of technological change among crops, market intervention, support by the government to certain crops but not to other crops, etc. The most significant of all these, however, is thought to be the changing relative prices of different crops. Thus an important task would be to compare the movements of relative prices of rice vs total cereals and rice vs wheat and examine the extent to which price movement would explain the pattern of movement of production. Presented in Diagram 2 are the results of our trend analysis showing the relative trends in observed and estimated values of prices of major cereals (i e, rice and wheat). Attention may first be drawn to the graphs for rice as percentage of total cereals. In this case, rise in prices of rice may be expected even though observed values of prices of rice do not reveal a tendency to increase definitely before 1982. It may, however, be seen from the same diagram that the prices of rice in relation to wheat prices have been increasing over time. Taking the results of these two diagrams together, we would be justified in these cases to interpret the result as indicating the trend of increasing relative prices of rice, although the relative production of rice has not been increasing during the intervening periods.

We may now turn our attention to the graphs relating to wheat prices. It is seen that the movement of wheat prices reveal a tendency to decline in relation to cereal prices and no clear pattern of change is discerned in relation to prices of rice. Trends in relative wheat production, presented in Diagram 1, however reveal a tendency to increase definitely during the post-green revolution period (1968-69 to 1984-85). Thus a very different and opposite pattern of the movement of production and prices of wheat is noticed which is not to be expected.

The price variable is something that is treated as a very sensitive indicator explaining the pattern of movement of production.

DIAGRAM 2: SHOWING OBSERVED AND ESTIMATED TIME TRENDS OF AGRICULTURAL INPUTS



The results of our analysis presented in Diagram 2 and also in Tables 3 and 4 are not in conformity with one's expectations. As Tables 3 and 4 show, the annual wholesale prices of both rice and wheat relative to cereal prices during the two periods under study have not increased significantly, although a significant increasing trend is observed in the prices of cereals. An interesting point to note here is the decrease in relative prices of wheat for both the pre- and post-green revolution periods and this decline in relative prices of wheat has not affected the growth of wheat production. It

TABLE 4: ESTIMATED LINEAR TREND EQUATIONS FOR RELATIVE PRICES OF MAJOR FOOD CROPS DURING 1968-69 TO 1984-85

Crops Compared	Estimated Parameters of Linear Trend Equation				
	Intercept	SE of Intercept	Slope	SE of Slope	R^2
(1) Ratio of rice to total cereals	0.9325*	0.0029	0.0136*	0.0052	0.3114
(2) Ratio of wheat to total cereals	0.9965*	0.0007	−0.0073*	0.0026	0.3539
(3) Ratio of rice to wheat	0.7230*	0.0065	0.0244*	0.0079	0.3892
(4) All cereals	76.7200	91.9458	9.8850	0.9358	0.8815

Notes: * Indicates significant at 1 per cent level of probability.

seems to us that it is not so much the price but some other factors such as change in technology, price policy, etc, which have helped the farmers to determine their cropping decisions.

In Tables 5 and 6 we present some results of simple linear regression estimates referring to the consumption of some agricultural inputs, viz, seeds, chemical fertilisers, irrigation, etc, during the pre- and post-green revolution periods. As the tables show, the time trends of the utilisation of major agricultural inputs for both the periods are statistically significant and the value of coefficient of multiple determination (R^2) is relatively high for the post-green revolution period. This is true of all the agricultural inputs considered with the exception of seeds which being a necessity might have reached saturation among the peasant families even in the earlier period. The structural break in the agricultural production technology may be located from the graphs presented in Diagram 3 showing the observed and estimated trend values of input/output ratio.

Attention may first be drawn to the graph showing seeds consumption as percentage of total agricultural output. The graph shows the declining trend of seeds consumption in relation to agricultural output, particularly in the post-green revolution period. In the case of fertiliser consumption, however, there seems to be a large difference between the two periods. As is to be expected, the graph shows that fertiliser consumption has been incresing very rapidly during the post-green revolution period. Similar pattern of movement is observed in the case of irrigation costs even though the movement of fertiliser consumption is faster than the movement of irrigation costs during 1968-69 to 1984-85. Thus it can be inferred from the analysis that the agricultural production technology, particularly the water-fertiliser technology, has positively influenced the increase in production of wheat resulting thereby in the changes in the compositional pattern of cereals production.

III
Summary and Conclusion

In this concluding section we take an overall view of the changing composition of foodgrains production under the changes that are taking place in the conditions of Indian agriculture in the light of the results presented in the preceding section.

The main empirical findings of the present exercise are that a structural break in the time trend in wheat production has taken place in the early seventies; that the relative stability of the production of rice has been hampered during the post-green revolution period; and that a sharp drop in the production of other cereals has occurred in the seventies. Trends in the composition of cereals production during the two phases of agricultural development (i e, the periods referring to before and after the introduc-

DIAGRAM 3: SHOWING OBSERVED AND ESTIMATED TIME TRENDS OF AGRICULTURAL PRICES

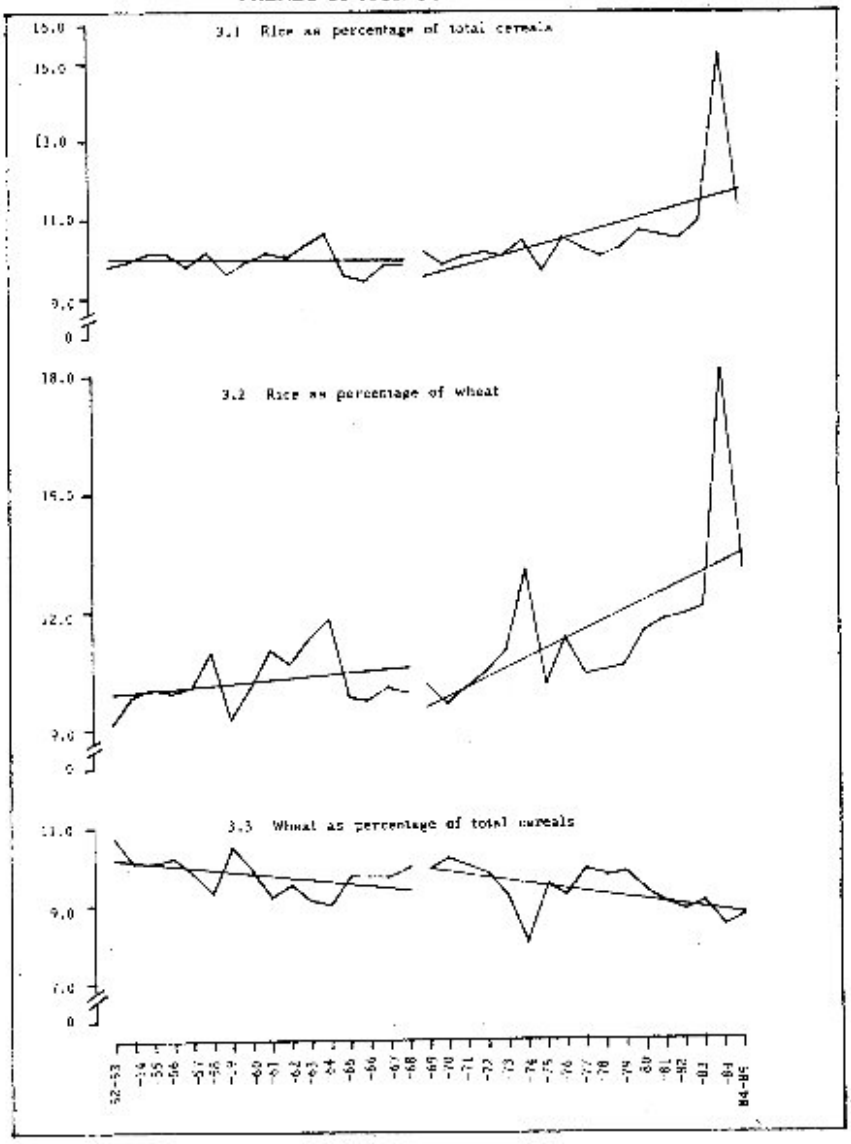


TABLE 5: ESTIMATED LINEAR TREND EQUATIONS FOR UTILISATION OF MAJOR AGRICULTURAL INPUTS DURING 1950-51 TO 1967-68

Inputs	Estimated Parameters of Linear Trend Equation				
	Intercept	SE of Intercept	Slope	SE of Slope	R^2
(1) Seeds	4.8641*	0.0098	−0.0240*	0.0092	0.2999
(2) Chemical fertilisers	−0.2320*	0.0198	0.0951*	0.0130	0.7695
(3) Irrigation	0.1441*	0.0002	0.0097*	0.0012	0.8121
(4) Electricity charges	−0.0259*	0.0002	0.0105*	0.0013	0.7979

Note: * Indicates significant at 1 per cent level of probability.

TABLE 6: ESTIMATED LINEAR TREND EQUATIONS FOR UTILISATION OF MAJOR AGRICULTURAL INPUTS DURING 1968-69 TO 1984-85

Inputs	Estimated Parameters of Linear Trend Equation				
	Intercept	SE of Intercept	Slope	SE of Slope	R^2
(1) Seeds	4.1498*	0.0049	−0.0284*	0.0069	0.5329
(2) Chemical fertilisers	1.3486*	0.0444	0.2767*	0.0206	0.9235
(3) Irrigation charges	0.2417	0.0018	0.0334*	0.0042	0.8104
(4) Electricity charges	0.1682*	0.0007	0.0583*	0.0026	0.9717

Note: * Indicates significant at 1 per cent level of probability.

tion of the new agricultural technology) are significantly different from each other and the breaks in the trends could not be explained only in terms of the movement of prices of the crops.[3]

The results of our analysis suggest that possibly the price factor does not play an important role in explaining the changes in cropping pattern. More specifically, the observed pattern of price movement is perhaps not a purely exogenous factor that induced changes in the composition of cereals production. A possible explanation for this could be as follows: The decision of a farmer on choosing a cropping pattern in his net revenue and not simply the price of the crop.[4] During the post-green revolution period most of the states started using various modern agricultural inputs which have led to increase the productivity of land under wheat crop in particular and thus increased the total wheat output. This increase in wheat output has helped to increase the net revenue of the farmers without increasing the market price of wheat. Thus wheat in the green revolution period has been treated as a preferred commodity in view of the productivity and return relative to other cereals, including rice.

Notes

[The authors have greatly benefited from discussions and suggestions from Dipankor Coondoo on an earlier draft of this paper.]

1 For an extensive review of earlier work on the growth rate of Indian agriculture, see Chattopadhyay and Bhattacharya [1986].

2 For a detailed discussion of this point, see Chattopadhyay and Battacharya [1986].

3 The results of our analysis are not in conformity with the argument that the price incentive approach is superior to the irrigation approach, as advanced by Tyagi [1986]. As to whether the relative increase in wheat production in the recent periods is insensitive to price changes or sensitive to agricultural technology cannot be answered from the aggregated data analysed here. However, one thing is clear from our analysis: agricultural technology plays an important role in explaining the recent production movement of cereal crops: relative prices of these crops may not necessarily result in increase in production.

4 Our observation and inference are consistent with the argument given by Dantwala [1986].

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Dantwala, M L [1986], 'Prices and Cropping Pattern', *Economic and Political Weekly*, Vol 21, No 16, April 19.

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