AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

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Batch 52

1. SUBJECT CLASSIFICATION
A. PRIMARY
B. SECONDARY

2. TITLE AND SUBTITLE
Growth of productivity in Indian agriculture

3. AUTHOR(S)
Narain,Dharm

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1976	58p.	ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
Cornell

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*
(In Occasional paper no.93)

9. ABSTRACT

The growth rate of productivity in Indian agriculture has risen substantially since the 1960's. This paper determined that contributing to this production increase are: 1) changes in cropping patterns, 2) locational shifts in the areas under crop, and 3) pure increases in yields from different states (due to the use of fertilizer). The percentage of the production increase attributed to each of the above factors is included. Another factor, the play of market prices in increasing productivity via specialization, was found weak unless aided by advanced technology. Accordingly, technological breakthroughs in the non-price worlds are far more significant than market prices. Tables, graphs, and formulas explain all analyses.

10. CONTROL NUMBER	11. PRICE OF DOCUMENT
PN-AAD-297	
12. DESCRIPTORS	13. PROJECT NUMBER
	14. CONTRACT NUMBER AID/nesa-G-1164
	15. TYPE OF DOCUMENT

AID 590-1 (4-74)

Occasional Paper No. 93

June 1976

GROWTH OF PRODUCTIVITY IN INDIAN AGRICULTURE

By

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ACKNOWLEDGEMENTS

This study was carried out during the year I spent as a Visiting Professor at Cornell University. I wish to express my gratitude to the Department of Agricultural Economics, Cornell University, for providing me with the means and facilities for the execution of this work, and to John W. Mellor for his continuing help and support which enabled me to spend this year so profitably. I am also grateful to C. Ranade, G. Doraswamy and D. S. Tyagi for their help in the preparation of this paper, to William G. Tomek and S. Chakravarty for their advice on some technical matters, and to Mohinder Mudahar and T. N. Srinivasan for their comments.

PREFACE

In recent years and under the influence of the green revolution, there has been a resurgence of emphasis on technological change as the engine of growth in agriculture. It has of course been concurrently noted that much of the new high yielding variety success has been in association with other inputs, particularly including irrigation. That brings our interest back to the broad question of the sources of agricultural production increase. Dharm Narain's painstaking and exceedingly thoughtful analysis of this question has much to teach us about not only the sources of growth, but leads up to important conclusions about the policies relevant to accelerated growth in agricultural production.

In our program at Cornell we have had a long series of empirical analyses of Indian economic growth specifically and agricultural development more generally. We are most fortunate to have had Dharm Narain with us for a year, during which time he carried out the analysis in this paper. He and this work bring great distinction to us and we are grateful for that.

We are also grateful to the Agency for International Development and its Asia Bureau for making a grant to Cornell for work in the area of this study which made it possible to free Dharm Narain's time uninterruptedly and to provide other facilities necessary to this work.

John W. Mellor

Ithaca, New York
June, 1976

CONTENTS

GROWTH OF PRODUCTIVITY IN INDIAN AGRICULTURE

By

Dharm Narain

I. Introduction

One thing that stands out in the growth performance of Indian agriculture since Independence is that while the sources of growth have changed over time, the overall growth rate of agricultural production has failed to get accelerated. In fact, despite technological change, the growth rate in the 1960's decelerated from the level attained in the 1950's. 1/ The principal factor pulling down the growth rate of agricultural output was of course the slowing down in the rate of expansion of cropped area. But the fact that even in the absence of technological change the growth rate of per hectare productivity in the 1950's got sufficiently stepped up to maintain the growth rate of output, 2/ whereas in the subsequent decade, despite technological change, the improvement in the growth rate of productivity turned out to be too small to even neutralize the effect of the slow-down in area expansion calls for a closer look into the sources of productivity growth. More specifically, it raises two questions: (1) What explains the comparatively sizeable growth of productivity in the 1950's when the benefits of technological change were yet not available? and (2) What accounts for only a modest step-up in the growth rate of productivity in the subsequent period which saw a far more substantial increase in fertilizer use than before, 3/ and specially since the mid-1960's when the area sown to the high yielding varieties of seeds started expanding to reach close to one-fifth of the total area under all foodgrains by 1972-73? In the process of seeking answers to these questions, we shall attempt to throw light on the role of price and non-price factors in productivity growth.

The concept of productivity adopted here is what has been customary in most of the literature on the growth of agricultural production in India, namely, the gross value of agricultural output in constant prices per hectare of gross cropped area. 4/ The index of productivity is thus defined as the

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[1]See C. H. Hanumantha Rao, Technological Change and Distribution of Gains in Indian Agriculture (Delhi: Macmillan Company of India, Ltd., 1975), pp. 3-4.

[2]See C. H. Hanumantha Rao, "Agricultural Growth and Stagnation in India," The Economic Weekly, February 27, 1965, p. 408.

[3]See Section VI, p. 33.

[4]For an exception, see Robert E. Evenson and Dayanand Jha, "The Contribution of Agricultural Research System to Agricultural Production in India," Indian Journal of Agricultural Economics, Vol. XXVIII, No. 4, Oct.-Dec. 1973, where changes in total factor productivity have been measured.

index of agricultural production divided by the index of area under crops. 1/ The index of agricultural production being $\frac{\sum_i A_{it} Y_{it} P_{io}}{\sum_i A_{io} Y_{io} P_{io}}$ and that of area being $\frac{\sum_i A_{it}}{\sum_i A_{io}}$, the index of productivity is of the form: $\frac{\sum_i C_{it} Y_{it} P_{io}}{\sum_i C_{io} Y_{io} P_{io}}$

where

A_{io} = area under the i^{th} crop in the base period

A_{it} = area under the i^{th} crop in the t^{th} year

Y_{io} = yield of the i^{th} crop in the base period

Y_{it} = yield of the i^{th} crop in the t^{th} year

P_{io} = price per unit of the i^{th} crop in the base period

$C_{io} = \frac{A_{io}}{\sum_i A_{io}}$ = area under the i^{th} crop as proportion of total cropped area in the base period

$C_{it} = \frac{A_{it}}{\sum_i A_{it}}$ = area under the i^{th} crop as proportion of total cropped area in the t^{th} year.

Since $Y_{it} = \frac{O_{it}}{A_{it}}$, where O_{it} = All-India production of the i^{th} crop in the t^{th} year and A_{it} = All-India area under the i^{th} crop in the t^{th} year,

$Y_{it} = \frac{\sum_s Y_{ist} A_{ist}}{\sum_s A_{ist}}$, where Y_{ist} = yield of the i^{th} crop in the s^{th} state in the t^{th} year and A_{ist} = area under the i^{th} crop in the s^{th} state in the t^{th} year.

[1] See, for example, Government of India, Directorate of Economics & Statistics, Ministry of Food and Agriculture, Growth Rates in Agriculture, 1968, p. 4.

Thus, if there is a relative shift of area under the i^{th} crop from states where its per hectare yields are lower to states where they are higher, it would impart a rising trend to its All-India yield even if its per hectare yields in the individual states remained unchanged over time. Similarly, a relative shift of the total cropped area away from crops with lower value of output per hectare towards crops with higher value of output per hectare would produce a rising trend in the index of productivity even if the per hectare yields of the individual crops remained unchanged over time. The growth of productivity is thus made up of three components respectively reflecting the contribution of (a) cropping pattern changes, (b) locational shifts of area under individual crops and (c) pure increases in the yields of individual crops in the different states.

We hypothesize that the growth of productivity within the framework of traditional technology was more importantly the result of the two types of area shifts referred to above than of the growth of per hectare yields of individual crops in the different states, whereas after the induction of modern technology it was more importantly the result of the latter than of area shifts. For examining the hypothesis, we need to decompose the index of productivity into its components. 1/ The next section outlines the methodology for doing so.

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[1] For a pioneering work in decomposing growth of agricultural output in India into its components, see B. S. Minhas and A. Vaidyanathan, "Growth of Crop Output in India: 1951-54 to 1958-61: an analysis by component elements," Journal of the Indian Society of Agricultural Statistics, Vol. XVII, No. 2, 1965.

II. Methodology of Decomposition*

As mentioned in the previous section, the index of productivity, I_t, is of the following form.

$$I_t = \frac{\sum_i C_{it} Y_{it} P_{io}}{\sum_i C_{io} Y_{io} P_{io}} \qquad \ldots (1)$$

Now $Y_{it} = \frac{\sum_s A_{ist} Y_{ist}}{\sum_s A_{ist}} = \frac{\sum_s A_{ist} Y_{ist}}{\sum_i \sum_s A_{ist}} \cdot \frac{\sum_i \sum_s A_{ist}}{\sum_s A_{ist}}$

$$= \sum_s C_{ist} Y_{ist} \frac{\sum_i \sum_s A_{ist}}{\sum_s A_{ist}},$$

where A_{ist} = area under the i^{th} crop in the s^{th} state in the t^{th} year,

Y_{ist} = yield of the i^{th} crop in the s^{th} state in the t^{th} year, and $C_{ist} = \frac{A_{ist}}{\sum_i \sum_s A_{ist}}$

Since $C_{it} = \frac{\sum_s A_{ist}}{\sum_i \sum_s A_{ist}}$

$$C_{it} Y_{it} = \sum_s C_{ist} Y_{ist}$$

Similarly,

$$C_{io} Y_{io} = \sum_s C_{iso} Y_{iso}$$

substituting $\sum_s C_{ist} Y_{ist}$ and $\sum_s C_{iso} Y_{iso}$ respectively for $C_{it} Y_{it}$ and $C_{io} Y_{io}$ in (1), we have

$$I_t = \frac{\sum_i \{\sum_s C_{ist} Y_{ist} P_{io}\}}{\sum_i \{\sum_s C_{iso} Y_{iso} P_{io}\}}$$

$$= \frac{\sum_i \sum_s \{(C_{ist} - C_{iso}) + C_{iso}\} \{(Y_{ist} - Y_{iso}) + Y_{iso}\} P_{io}}{\sum_i \sum_s C_{iso} Y_{iso} P_{io}}$$

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*I owe the derivation of the formula for decomposition to C. Ramasamy

$$= \frac{\Sigma\Sigma_{is}(C_{ist}-C_{iso})(Y_{ist}-Y_{iso})P_{io}+\Sigma\Sigma_{is}(C_{ist}-C_{iso})Y_{iso}P_{io}+\Sigma\Sigma_{is}C_{iso}(Y_{ist}-Y_{iso})P_{io}+\Sigma\Sigma_{is}C_{iso}Y_{iso}P_{io}}{\Sigma\Sigma_{is}C_{iso}Y_{iso}P_{io}}$$

$$= 1 + [\Sigma_i \Sigma_s (C_{ist}-C_{iso})(Y_{ist}-Y_{iso})P_{io} + \Sigma_i \Sigma_s (C_{ist}-C_{iso}) Y_{iso}P_{io} + \Sigma_i \Sigma_s C_{iso}(Y_{ist}-Y_{iso})P_{io}] / \Sigma_i \Sigma_s C_{iso}Y_{iso}P_{io}$$

The numerator of the expression inside the brackets $\{\}$ consists of

$$\Sigma_i \Sigma_s (C_{ist}-C_{iso}) Y_{iso}P_{io} \quad \ldots \quad (A)$$

$$\Sigma_i \Sigma_s (C_{ist}-C_{iso})(Y_{ist}-Y_{iso}) P_{io} \quad \ldots \quad (B)$$

and $$\Sigma_i \Sigma_s C_{iso}(Y_{ist}-Y_{iso}) P_{io} \quad \ldots \quad (C)$$

Since $C_{it} = \frac{\Sigma A_{ist}}{\Sigma\Sigma A_{ist}}$, $C_{ist} = \frac{A_{ist}}{\Sigma\Sigma A_{ist}}$, and $d_{ist} = \frac{A_{ist}}{\Sigma A_{ist}} =$

area under the i^{th} crop in the s^{th} state as proportion of the All-India area under the i^{th} crop in the t^{th} year,

$$C_{ist} = \frac{A_{ist}}{\Sigma\Sigma A_{ist}} \cdot \frac{\Sigma A_{ist}}{\Sigma A_{ist}} = d_{ist}C_{it}$$

Similarly, $C_{iso} = d_{iso}C_{io}$

Substituting $d_{ist}C_{it}$ and $d_{iso}C_{io}$ respectively for C_{ist} and C_{iso} in (A),

we have $\Sigma_i \Sigma_s (C_{ist}-C_{iso})Y_{iso}P_{io} = \Sigma_i \Sigma_s (C_{it}d_{ist}-C_{io}d_{iso}) Y_{iso}P_{io}$

$$= \Sigma_i \Sigma_s \{[(C_{it}-C_{io})+C_{io}][(d_{ist}-d_{iso})+d_{iso}] - C_{io}d_{iso}\}Y_{iso}P_{io}$$

$$= \Sigma\Sigma_{is}\{(C_{it}-C_{io})(d_{ist}-d_{iso})+(C_{it}-C_{io})d_{iso}+C_{io}(d_{ist}-d_{iso})+C_{io}d_{iso}-C_{io}d_{iso}\}Y_{iso}P_{io}$$

$$= \Sigma\Sigma_{is}\{(C_{it}-C_{io})(d_{ist}-d_{iso})+(C_{it}-C_{io})d_{iso}+C_{io}(d_{ist}-d_{iso})\}Y_{iso}P_{io} \quad \ldots \quad (2)$$

Substituting the expression inside the brackets $\{\}$ in (2) for $(C_{ist}-C_{iso})$ in (B), we have

$$\sum_{is}\sum(C_{ist}-C_{iso})(Y_{ist}-Y_{iso})P_{io} = \sum_{is}\sum(C_{it}-C_{io})(d_{ist}-d_{iso})(Y_{ist}-Y_{iso})P_{io}$$

$$+ \sum_{is}\sum C_{io}(d_{ist}-d_{iso})(Y_{ist}-Y_{iso})P_{io}$$

$$+ \sum_{is}\sum(C_{it}-C_{io})d_{iso}(Y_{ist}-Y_{iso})P_{io}$$

Finally, substituting $C_{io}d_{iso}$ for C_{iso} in (C), we have

$$\sum_{is}\sum C_{iso}(Y_{ist}-Y_{iso})P_{io} = \sum_{is}\sum C_{io}d_{iso}(Y_{ist}-Y_{iso})P_{io}$$

Hence,

$$I_t = 1+\{\sum_{is}\sum C_{io}d_{iso}(Y_{ist}-Y_{iso})P_{io}+\sum_{is}\sum C_{io}(d_{ist}-d_{iso})Y_{iso}P_{io}$$

$$+ \sum_{is}\sum(C_{it}-C_{io})d_{iso}Y_{iso}P_{io}$$

$$+ \sum_{is}\sum(C_{it}-C_{io})(d_{ist}-d_{iso})Y_{iso}P_{io}$$

$$+ \sum_{is}\sum(C_{it}-C_{io})d_{iso}(Y_{ist}-Y_{iso})P_{io}$$

$$+ \sum_{is}\sum C_{io}(d_{ist}-d_{iso})(Y_{ist}-Y_{iso})P_{io}$$

$$+ \sum_{is}\sum(C_{it}-C_{io})(d_{ist}-d_{iso})(Y_{ist}-Y_{iso})P_{io}\}/\ \sum_{is}\sum C_{io}d_{iso}Y_{iso}P_{io}$$

In the numerator of the expression inside the brackers {},

$\sum_{is}\sum C_{io}d_{iso}(Y_{ist}-Y_{iso})P_{io}$ represents the <u>pure yield effect</u>; it measures the changes in productivity that would have occurred as a result of variations in the per hectare yields of the individual crops in the different states in the absence of changes in the cropping pattern and the locational shifts in the areas under individual crops;

$\sum_{is}\sum C_{io}(d_{ist}-d_{iso})Y_{iso}P_{io}$ represents the <u>pure locational shift effect</u>; it measures the changes in productivity that would have occurred as a result of locational shifts in the areas under individual crops in the absence of changes in the cropping pattern and the per hectare yields of individual crops;

$\sum_{is}\sum(C_{it}-C_{io})d_{iso}Y_{iso}P_{io}$ represents the <u>pure cropping pattern shift effect</u>; it measures the changes in productivity that would have occurred as a result of changes in the cropping pattern in the absence of locational shifts and variations in the per hectare yields of crops;

and the remaining four terms represent the effect on productivity of interactions resulting from simultaneous changes in two or more of the three factors mentioned above.

Since we wish to focus on the picture that would have been if the cropping pattern changes and locational shifts respectively had not occurred, even though interactions result from simultaneous changes in two or more of the three factors involved, we have clubbed together $\Sigma\Sigma_{is}(C_{it}-C_{io})(d_{ist}-d_{iso})Y_{iso}P_{io}$, $\Sigma\Sigma_{is}(C_{it}-C_{io})d_{iso}(Y_{ist}-Y_{iso})P_{io}$, and $\Sigma\Sigma_{is}(C_{it}-C_{io})(d_{ist}-d_{iso})(Y_{ist}-Y_{iso})P_{io}$, which get reduced to $\Sigma_{i}(C_{it}-C_{io})(Y_{it}-Y_{io})P_{io}$, [1/] as the cropping pattern interaction to be considered alongside of the pure cropping pattern effect. The interaction represented by $\Sigma\Sigma_{is}(d_{ist}-d_{iso})(Y_{ist}-Y_{iso})P_{io}$ has, likewise, been called the locational interaction to be considered alongside of the pure locational effect.

The index of productivity we decompose is based on the same data pertaining to area and production on which the official series of index numbers of agricultural production and area rest, and has the same base period, namely, the triennium ending 1961-62, as the official series. Unlike the official index numbers, however, which now cover 38 crops, our index is confined to 32 crops owing to the non-availability of data for a few minor crops for the earlier years. For measuring the locational shift effect, we needed state-wise data for area and production. But since this was available on a comparable basis for only the 18 principal crops, we have been able to separate the locational shift effect from the pure changes in per hectare yield for only these crops. And even for these crops the data was available for only the states in which a crop is importantly grown. By substracting from the All-India area and production respectively the sum total of the area and production of the principal states for each crop, we have worked out its area and production for the rest of India. While aggregating the changes in per hectare yields for the 32 crops, however, we have taken the variations as

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1 $\Sigma\Sigma_{is}(C_{it}-C_{io})P_{io}\{(d_{ist}-d_{iso})Y_{iso}+d_{iso}(Y_{ist}-Y_{iso})+(d_{ist}-d_{iso})(Y_{ist}-Y_{iso})\}$

$= \Sigma\Sigma_{is}(C_{it}-C_{io})P_{io}(d_{ist}Y_{iso}-d_{iso}Y_{iso}+d_{iso}Y_{ist}-d_{iso}Y_{iso}+d_{ist}Y_{ist}-d_{ist}Y_{iso}-d_{iso}Y_{ist}+d_{iso}Y_{iso})$

$= \Sigma\Sigma_{is}(C_{it}-C_{io})P_{io}(d_{ist}Y_{ist}-d_{iso}Y_{iso})$

$= \Sigma_{i}(C_{it}-C_{io})P_{io}(Y_{it}-Y_{io})$ $\quad \because Y_{it}=d_{ist}Y_{ist}$ and $Y_{io}=d_{iso}Y_{iso}$

they are in All-India yields of the remaining 14 crops. Our 'pure' yield effect is thus only partially pure but since the 18 principal crops account for an overwhelmingly large proportion of the total cropped area, it may be taken to be a fair approximation to the true picture. The results of decomposition are summarized in the next section.

III. The Results

We present the results of decomposition both in terms of the absolute changes in per hectare productivity valued at constant prices of the base period and in terms of the growth rates of the index numbers of productivity. The time-span covered by our statistical series is dictated by the availability of data. Since the state-wise data for the area and production of crops was not available on a comparable basis for the period prior to 1952-53 and the latest year for which it could be had was 1972-73, our series of overall productivity and its components cover the period 1952-53 to 1972-73. To test our hypothesis, we have split the period into two parts: (1) 1952-53 to 1960-61 and (2) 1961-62 to 1972-73. The reason for this split-up is that increases in fertilizer use became sizeable only during the 1960's and the high yielding varieties of seeds started gaining ground from the mid-1960's. For considering absolute changes in productivity and its components, however, it is more convenient to let the base period, consisting of the triennium ending 1961-62, serve as the dividing line. To reduce the effect of weather-induced short-term fluctuations, we present in Table 1 the averages of the annual values for the triennia ending 1954-55 and 1972-73.

The results lend a striking support to our hypothesis. Almost 70 percent of the increase in productivity in the first period was produced by changes in the cropping pattern and the locational shifts of areas under individual crops and only about 30 percent by the pure increases in per hectare yields. The picture underwent a reversal in the second period with pure increases in yields accounting for over 60 percent of the increase in productivity while cropping pattern changes and locational shifts accounted for under 40 percent of the increase.

The growth rates of productivity and of its components for the two periods tell a similar story (Table 2). While the growth rate for the index of pure yields was only about 30 percent of that for the overall index of productivity in the first period, it shot up to around 65 percent of the growth rate for the latter in the second period. Thus, when the wherewithals for substantial increases in yields were lacking the bulk of productivity growth came from the different kinds of relative shifts in area but when the crops received more and more plant nutrients and the new seed technology started shifting the production functions upwards, pure increases in yields became the major source of productivity growth. Indeed, compared to the first period, the growth rate for pure yields underwent a two and a half fold step-up in the second period. If in spite of that, the growth rate of productivity improved only moderately, 1/ it was, in part, because the relative weight of the pure yield component in the overall growth of productivity

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[1] 1972-73 having been a year of severe drought, if we exclude this year, the growth rate of productivity for the second period works out to 2.27 percent per annum. But even after this exclusion, the step-up in the growth rate for this period over that for the first remains modest.

Table 1. Absolute Changes in Productivity per Hectare (in Rupees)

Period*	Cropping pattern effect			Locational effect			Pure yield effect	Total
	Pure (a)	Interaction (b)	(a) + (b)	Pure (c)	Interaction (d)	(c) + (d)		
Av. for triennium ending 1954-55	-14.43	1.01	-12.42 (35.2)	-2.06	-9.74	-11.80 (33.8)	-10.75 (30.9)	-34.97
Av. for triennium ending 1961-62	0	0	0	0	0	0	0	0
Av. for triennium ending 1972-73	15.55	7.83	23.38 (30.5)	3.37	2.97	6.34 (8.3)	46.85 (61.2)	76.56

*While the zero values for the base period represent the averages for the three years ending 1961-62 considered together, the values for the other two triennia represent the averages for the individual years. Figures in parenthesis represent percentages of the total in the last column. Figures in the individual columns may not exactly add up to the total due to rounding.

Table 2. Productivity and Its Components: Growth Rates (Compound)*

Period	1952-53 to 1960-61	1961-62 to 1972-73	1952-53 to 1972-73
Cropping Pattern Effect	0.44	0.60	0.52
Pure	0.48	0.38	0.44
Interaction	-0.04	0.23	0.08
Locational Effect	0.54	0.24	0.26
Pure	0.10	0.08	0.10
Interaction	0.44	0.16	0.16
Pure Yield Effect	0.54	1.33	0.83
Overall Productivity	1.58	2.07	1.60

*Obtained by fitting the standard form $Y=ab^t$ to the time-series of the index numbers of productivity and its components by ordinary least squares.

was, to begin with, rather small. For the other part, the explanation belongs in the declining contribution of locational shifts to productivity growth and in the decline, albeit small, in the pure effect of cropping pattern changes which moderated the improvement in the overall contribution of cropping pattern changes to productivity growth. What lay behind these phenomena is the subject of investigation in the next two sections.

IV. Cropping Pattern Changes and Growth of Productivity

As has already been seen in the preceding section, it was the pure cropping pattern effect which contributed to the growth of productivity in the first period, the interaction effect having been negative and rather small. It would further be seen from Table 3 that the percentage distribution of the total cropped area among crops did not undergo any dramatic changes in this period but since the inter-crop differences in the value of output per hectare are large, even limited changes in the relative shares of individual crops in the total cropped area tended to produce a significant effect on productivity growth. The highlights of these changes may be summarized as follows. The low value coarse grains, specially jowar and bajra lost in terms of their relative share while the higher value superior cereal, wheat, made an accretion to its share. Even more significant is the fact that foodgrains as a whole lost to the tune of 1.3 percentage points while the non-foodgrain crops gained and since the latter have generally much higher values of output per hectare than the foodgrains, this shift produced a good part of the increase which cropping pattern change contributed to per hectare productivity during this period. Table 4 which gives a cropwise breakdown of the pure cropping pattern effect helps identify the crops which played a leading part in this increase. Among such crops, sugarcane emerges as the most important one to be followed by groundnut and wheat, and then by jute and mesta 1/ (considered together), potato, rape and mustard and gram. What brought about a relative decline in the area under millets and a relative increase in the area under these other crops is the question to which we must address ourselves. But before we do so, we need to bring together in a comparative setting, the highlights of cropping pattern change during the second period.

The most dramatic change in the latter period was registered by wheat; it increased its relative share in the total area under all crops from 8.7 percent to 12.0 percent. This order of increase, testifying to the pull of the new technology, has not been witnessed for any other crop in either of the two periods. Within the foodgrain group, bajra which was losing in terms of its relative weight in the cropping pattern in the first period improved its position in the second. Maize which had earlier improved its share only mildly now did so more significantly. And the percentage share of rice, compared to the picture of constancy in the first period, now registered an increase. Associated with the increase in the share of wheat is the decline in the second period - compared to a moderate improvement in the first - in the percentage share of pulses. Jowar and other coarse grains which were losing in terms of their relative share even in the first period continued to do so in the second. In the upshot, foodgrains as a whole, which had earlier suffered a loss in their percentage share, were able to nearly hold their ground in the subsequent period. In fact, the positive pure cropping pattern effect attributable to wheat is so large in the second period that even when netted for the negative effect of pulses, the latter being lower value crops, it remains sizeable though it gets considerably diluted. The positive effect of rice and maize too being substantial, the pure cropping pattern effect of

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[1] Mesta is an inferior substitute of jute.

Table 3. Cropping Pattern and Value of Output per Hectare

	Value of output (in Rupees), average for triennium ending 1961-62	Cropping pattern (in percentages) Average for triennium ending		
		1954-55	1961-62	1972-73
Rice	557.10	22.43	22.50	23.25
Jowar	177.54	12.86	11.92	10.22
Bajra	124.32	8.37	7.33	7.60
Maize	298.18	2.74	2.91	3.60
Ragi	296.95	1.68	1.65	1.50
Wheat	344.17	7.74	8.74	11.95
Barley	264.06	2.48	2.17	1.55
Small millets	112.90	3.98	3.28	2.81
Gram	217.15	5.96	6.39	4.74
Tur	285.37	1.76	1.60	1.53
Other pulses	129.91	7.75	7.93	7.32
Groundnut	433.34	3.55	4.34	4.53
Sesasum	160.29	1.85	1.44	1.47
Rape & mustard	311.61	1.65	1.26	2.16
Linseed	145.31	1.00	1.26	1.19
Castor	144.63	0.40	0.32	0.27
Coconut	1376.75	0.47	0.47	0.67
Cotton seed	77.62	5.09	5.02	4.82
Cotton (lint)	232.47	5.09	5.02	4.82
Jute	982.67	0.42	0.49	0.47
Mesta	513.48	0.14	0.22	0.19
Tea	4761.56	0.23	0.22	0.22
Coffee	1314.54	0.07	0.08	0.09
Rubber	472.03	0.05	0.09	0.13
Pepper	748.82	0.06	0.07	0.08
Chillies	1327.32	0.41	0.41	0.46
Ginger	993.37	0.01	0.01	0.02
Turmeric	2307.32	0.03	0.03	0.05
Potato	1939.85	0.19	0.24	0.34
Banana	3091.18	0.10	0.11	0.14
Sugarcane	1949.60	1.16	1.54	1.55
Tobacco	1792.92	0.26	0.27	0.28
Foodgrains		77.75	76.42	76.07
Non-foodgrains		22.23	23.61	23.95

In view of the non-availability of the prices for kapas (unginned cotton) for the base period, cotton lint and cotton seed figure as separate commodities in the index of agricultural production and hence in the index of productivity. The double counting of cotton area, however, makes the above picture of the cropping pattern somewhat inaccurate even though the error involved is small. But since this is what enters into the index of productivity and, in any case, does not alter the essential features of cropping pattern change, we have presented it on the same basis.

Table 4. Cropping Pattern Effect
Absolute Changes in Productivity as Measured from the Base Period (triennium ending 1961-62=0) in Rupees

Crop	Pure		Interaction	
	Average for triennium ending 1954-55	1972-73	Average for triennium ending 1954-55	1972-73
Rice	-0.34	4.17	0.02	0.50
Jowar	1.69	-3.03	-0.12	0.23
Bajra	1.29	0.33	0.04	0.25
Maize	-0.51	2.07	0.00	0.34
Ragi	-0.07	-0.46	-0.02	-0.05
Wheat	-3.46	11.10	0.24	6.24
Barley	0.83	-1.64	-0.02	-0.29
Millets	0.79	-0.54	0.04	0.05
Gram	-0.96	-3.61	0.02	-0.26
Tur	0.45	-0.21	0.04	-0.01
Other pulses	-0.22	-0.79	-0.02	0.06
Groundnut	-3.40	0.83	-0.04	0.09
Sesasum	0.65	0.06	0.16	0.02
Rape & mustard	-0.97	0.60	0.03	0.09
Linseed	-0.37	-0.10	-0.07	-0.01
Castor seed	0.12	-0.07	-0.01	-0.03
Coconut	0.06	2.76	0.01	-0.35
Cotton seed	0.05	-0.15	0.00	-0.03
Cotton lint	0.16	-0.44	0.01	-0.08
Jute	-0.62	-0.15	0.04	0.00
Mesta	-0.41	-0.14	0.01	0.01
Tea	0.60	0.27	-0.04	0.06
Coffee	-0.09	0.17	0.02	0.11
Rubber	-0.17	0.21	-0.07	0.55
Pepper	-0.03	0.07	0.00	-0.01
Chillies	-0.06	0.63	0.01	0.02
Ginger	-0.01	0.02	0.00	0.01
Turmeric	0.14	0.45	0.02	-0.06
Potato	-1.01	1.37	-0.06	0.30
Banana	-0.31	0.98	0.02	-0.06
Sugarcane	-7.28	0.53	0.75	0.07
Tobacco	-0.11	0.19	0.00	0.03
Foodgrains	-0.11	2.22		
Non-foodgrains	-3.92	2.43		

foodgrains as a group turns out to be far larger than in the first period. The secret of the mild decline in the overall pure cropping pattern effect lies in the considerable decline in the contribution of the non-foodgrain crops in view of only a slight gain in their overall share in the total cropped area.

From among the non-foodgrain crops which had made a leading contribution to the overall increase in the pure cropping effect in the first period, rape and mustard continued to improve its relative weight in the cropping pattern but the improvement in sugarcane and groundnut got nearly halted and jute and mesta even lost in terms of their relative share thus contributing to a substantial step-down in the positive pure cropping pattern effect of the non-foodgrain crops in the second period.

The picture of interaction effect is simple with one crop dominating the scene. The increase in the percentage share of wheat in the cropping pattern was so dramatic and so also the increases in its per hectare yield that this crop became the source of bulk of the overall positive interaction effect in the second period, the other crops producing relatively small and, in a large part, mutually offsetting interaction effects.

What factors brought about these shifts and how importantly were they price and non-price factors is the question to which we must now turn.

Among the non-price factors, apart from the new technology, the expansion of irrigation is an important force bearing upon cropping pattern change. Alongside of the extension of irrigation, however, there has also occurred the expansion of total cropped area and since the cropping pattern in the different regions is, inter-alia, conditioned by the soil-climatological conditions therein, the location of expansion in cropped area too bears upon the changes in the All-India cropping pattern. The reasoning underlying our method for examining the effect of the expansion of irrigated-cum-total cropped area is simple: if this is the only force working, the cropping pattern which, to begin with, obtains in the irrigated and unirrigated areas of each soil-climatologically homogeneous region would be expected to reproduce itself on the additions made to the irrigated and unirrigated cropped area in that region. 1/ Although ideally one must proceed on the basis of homogeneous regions, such an exercise is too ambitious to be attempted here. We therefore worked out the percentage distribution among crops of the irrigated and unirrigated area in each state for the triennium ending 1954-55. On the basis of this initial distribution, we then allocated to different crops the total irrigated and unirrigated area respectively in each of the subsequent years in each state. Aggregating the irrigated and unirrigated area components of each crop in all the states in each year, we arrived at the time series for the area under the different crops. Expressing the so

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[1] This is on the assumption that complementary inputs do not constitute a constraint. But since labor is the most important complementary input in the context specially of traditional technology, it is safe to assume that in a labor-abundant economy it would not constitute a constraint.

estimated All-India area under each crop as percentage of the All-India gross cropped area for each year, we obtained the changes in the cropping pattern that would be expected to have occurred under the impact of changes in the total irrigated-cum-cropped area and in the absence of the play of factors such as relative prices.

To examine the effect of prices on cropping pattern changes, we deflated the price relatives for the different crops by the index of agricultural commodity prices specially constructed for the purpose. 1/ Strictly speaking, the prices relevant to the farmer's decision-making in regard to the allocation of area among crops are the expected rather than the actual prices. But since expectations are believed to be colored the most by relatively recent experience, it is the prices one or two seasons preceding current sowings which may be expected to play a predominant part in influencing the inter-crop allocation of area.

It would be seen from Figure 1 that while the downward drift in the percentage share of jowar in the total area under crops does not have its counterpart in the curve of deflated price, it is matched by a similar drift in the hypothetical percentage shares computed on the basis of the above exercise. Since information pertaining to irrigated and unirrigated areas is available only in Land Use Statistics, we have had to base this exercise on this set of statistics rather than that on which the index of productivity and the actual area shares of the different crops rest. Although differences in the geographical and commodity coverage of the two sets of statistics vitiate comparability between the levels of the percentage shares in the two cases, the fact that the declining trend in the actual shares faithfully emerges in the hypothetical shares inspires confidence in the inference that it was the expansion of irrigation-cum-cropped area rather than price which brought about the decline in the relative share of jowar in the total cropped acreage.

In the case of bajra which was losing its weight in the cropping pattern in the earlier years but improved it in the later years, the change is not explained by either the behavior of the hypothetical shares or by the deflated price of this crop (Figure 2). However, since groundnut competes with bajra for area, it is significant that bajra lost in terms of its relative share during the period when groundnut was gaining and this upward drift in the case of groundnut got arrested and even a certain decline ensued when bajra improved its share (Figure 3). As we look for the explanation of these mutually related changes, we find that while the behavior of the hypothetical shares for groundnut - which trace a downward course throughout - does not explain the improvement in its actual share, the deflated price does but it does not explain why

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[1] The index represents the unweighted geometric mean of the percentage relatives of the prices of 14 leading agricultural commodities-unweighted because as we have argued earlier in Impact of Price Movements on Areas under Selected Crops in India: 1900-1939 (Cambridge University Press, 1965), pp. 12-17, any system of weighting adopted in the construction of the index for the purpose is arbitrary.

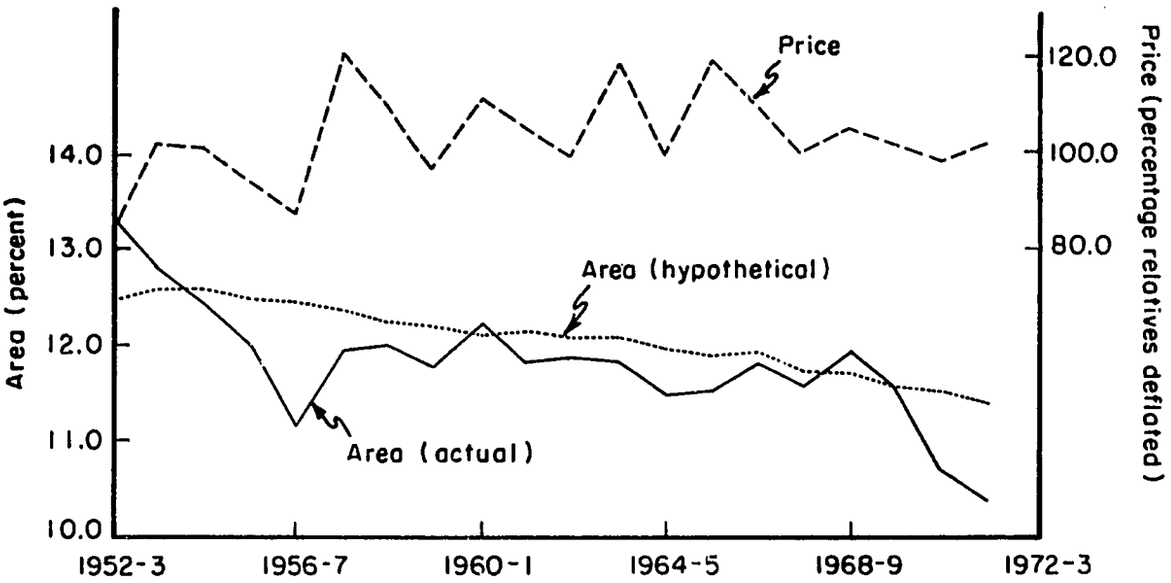

Figure 1. Jowar area as percent of total cropped area and percentage relatives of jowar prices deflated. Plotted against the area percentage for a year is the price for the preceding year. The time scale refers to area.

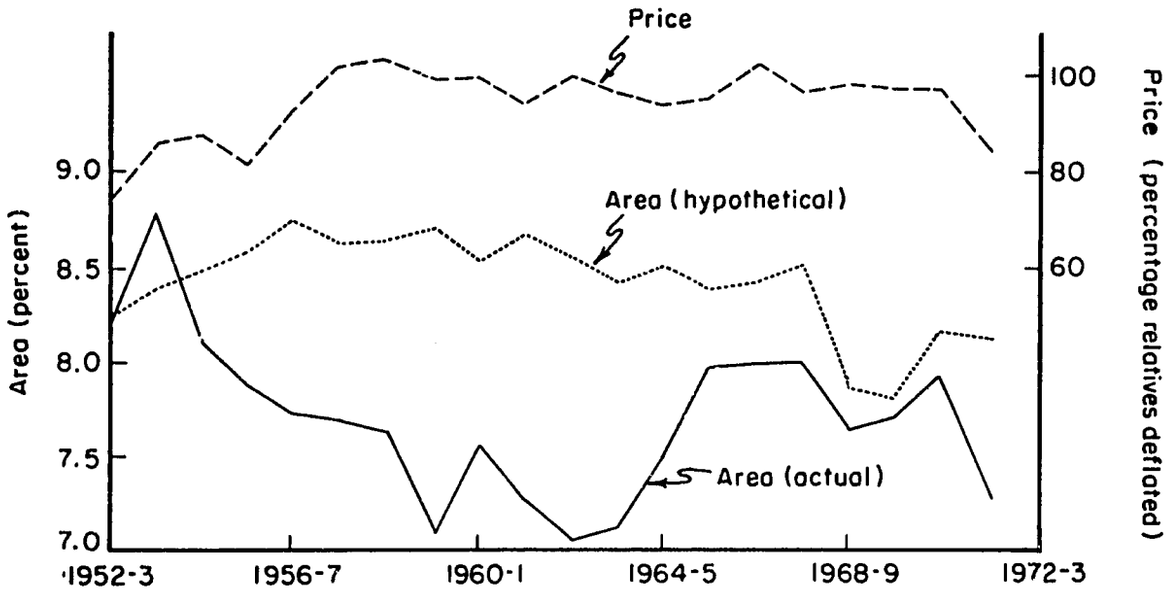

Figure 2. Bajra area as percent of total cropped area and percentage relatives of bajra prices deflated. Plotted against the area percentage for a year is the price for the preceding year. The time scale refers to area.

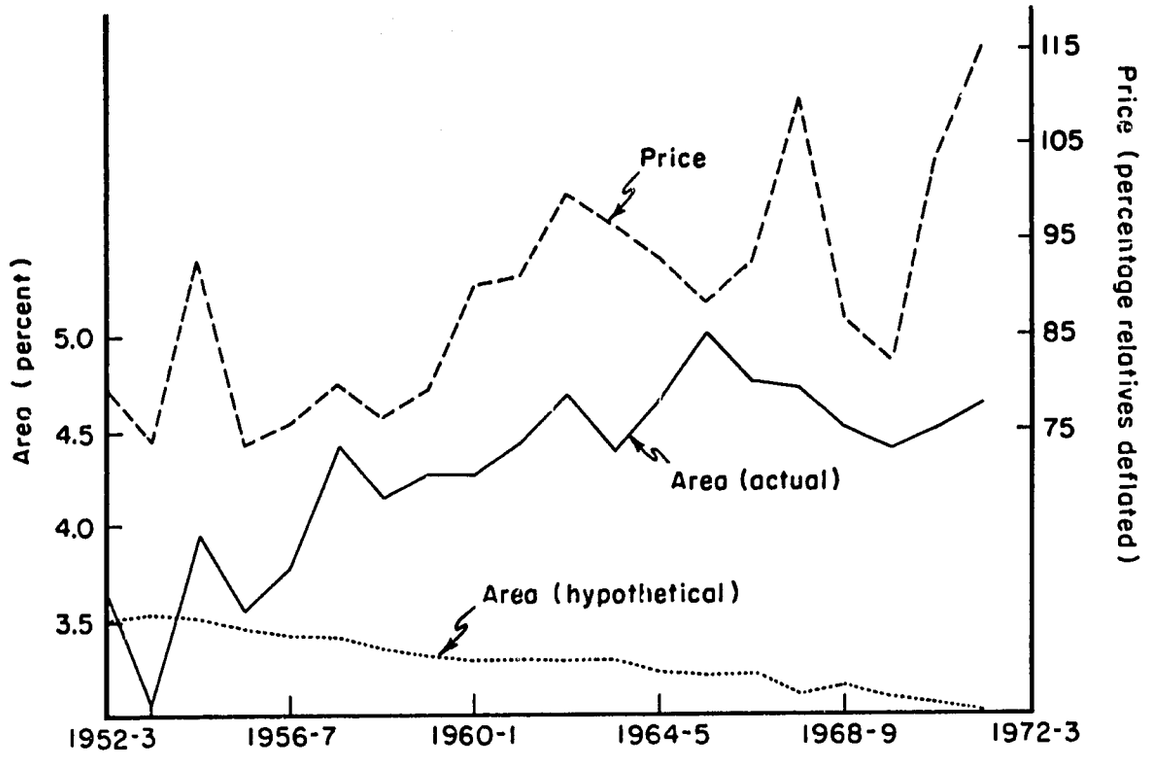

Figure 3. Groundnut area as percent of total cropped area and percentage relatives of groundnut prices deflated. Plotted against the area percentage for a year is the price for the preceding year. The time scale refers to area.

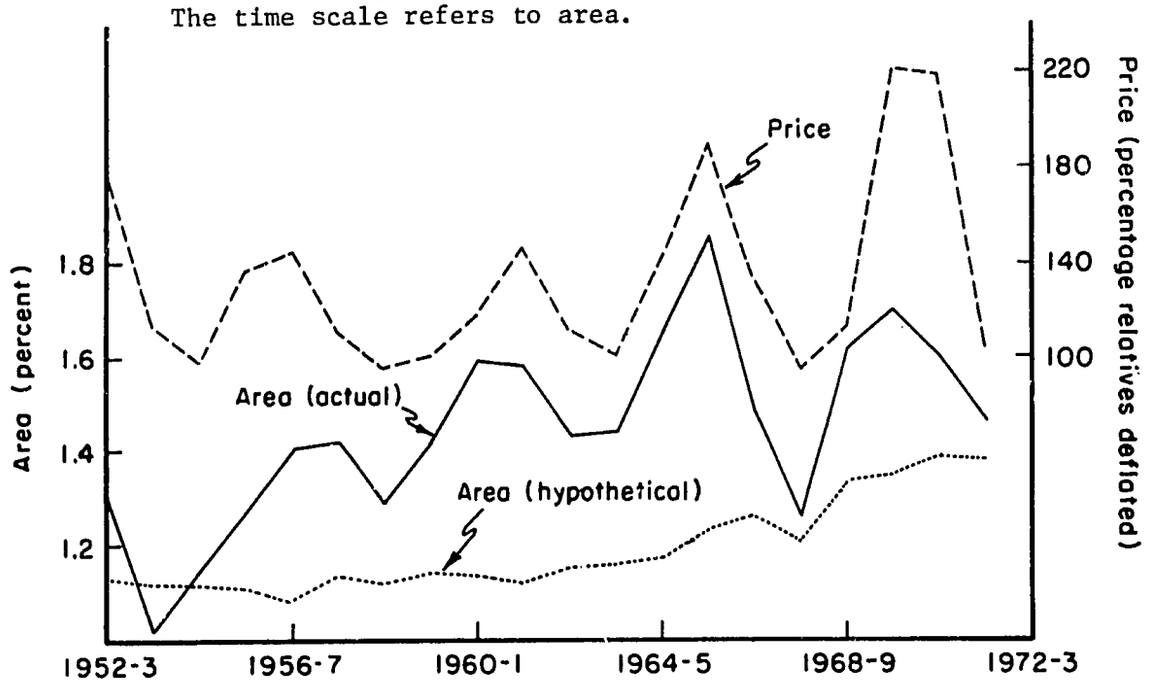

Figure 4. Sugarcane area as percent of total cropped area and percentage relatives of gur prices deflated. Plotted against the area percentage for 1952-53 is the price for 1950-51 and so on. The time scale refers to area.

this improvement suffered a setback after the mid-1960's. Significantly enough, this is the period in which the high-yielding varieties of seeds caught on and bajra being only next to wheat in the successes achieved with these varieties, it was apparently under the stimulus of technological change that the area under this crop expanded fast enough to improve its relative weight in the cropping pattern and applied a brake on the further improvement in the share of groundnut. Since the deflated price of groundnut continued its upward drift even during this period, it is clear that in the mutual tug of war between the force of technological change and that of price, the latter got worsted.

Sugarcane acreage is subject to cyclical oscillations and these find their manifestation in the curve of its percentage share in the total cropped area. Up to the mid-1960's, the drift underlying these oscillations, however, is unmistakably upward (Figure 4). But it accompanies a downward drift in the deflated price of sugarcane. Unfortunately, the index of sugarcane prices being based on the statutory minimum prices for cane rather than those actually paid by the sugar factories is unsatisfactory. We have used therefore instead the index of gur (jaggery) prices. While the deflated price of gur, with a time lag of sometimes one but mostly two years, explains the oscillations in the percentage share of sugarcane acreage in the total cropped area, 1/ it does not account for the rising drift therein during the first period. Nor does the series of hypothetical percentage shares explain this development. We have shown elsewhere 2/ that the sugarcane acreage in the pre-Independence period had expanded under the stimulus of demand emanating from the growth of the sugar industry and since this industry continued to expand, it appears that it was a continuation of the same development in the post-Independence period. The rise in the peak of the third cycle in the curve of the percentage share over that of the preceding one has its match in the corresponding peaks of deflated price but the subsequent area cycle stands bodily lower despite a further increase in the peak of deflated price. And this is what is reflected in the absence of any further improvement in the relative weight of sugarcane in the cropping pattern in the second period. Since wheat competes with sugarcane for area, and this development occurred after the mid-1960's when the high-yielding varieties of this cereal rapidly gained ground in the northern sugarcane producing states, it is the enhanced competitive pull of wheat which lies behind the halt in the improvement in the relative weight of sugarcane in the cropping pattern during this period.

The increase in the percentage share of wheat in the total cropped area during the first period is not explained by the deflated price (Figure 5). And the improvement in the hypothetical share of this crop too is quite mild. It could well be that the expansion of wheat area reflects in addition the increase in cropping intensity taking the form of raising a rabi crop after

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[1] That the price-area cycles in the case of this crop portray in essentials the working of the cobweb theorem is argued in Dharm Narain, Impact of Price Movements on Areas under Selected Crops in India: 1900-1939, (Cambridge University Press, 1965), pp. 86-102.

[2] Ibid., pp. 102-106.

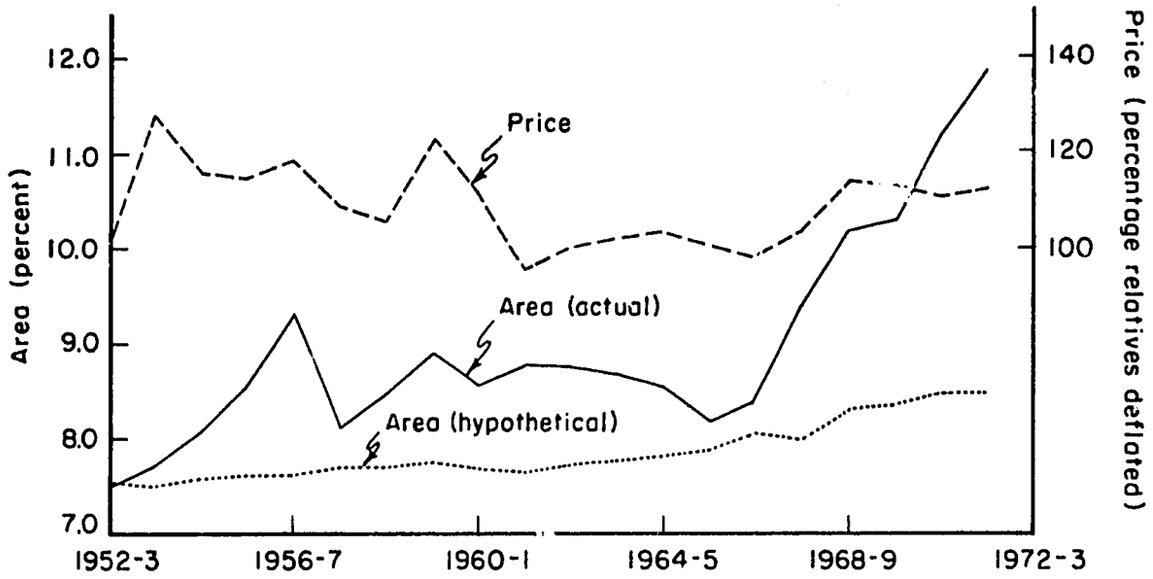


Figure 5. Wheat area as percent of total cropped area and percentage relatives of wheat prices deflated. Plotted against the area percentage for a year is the price for the preceding year. The time scale refers to area.

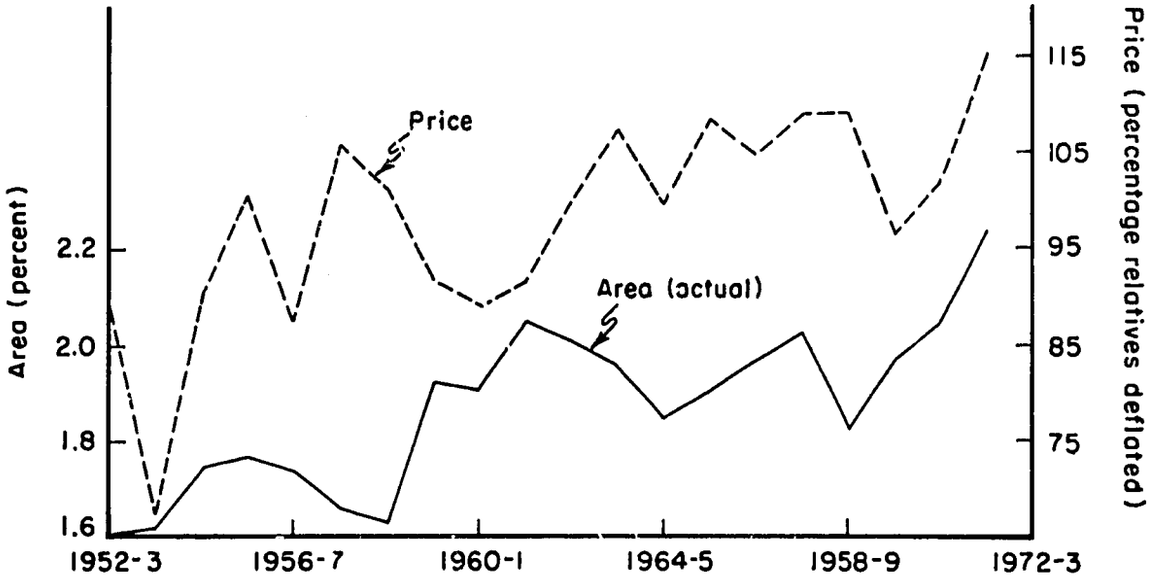


Figure 6. Rape and mustard area as percent of total cropped area and percentage relatives of rape and mustard prices deflated. Plotted against the area percentage for a year is the price for the preceding year. The time scale refers to area.

the kharif on an increasing proportion of the net cropped area which our exercise for reaching the hypothetical shares, being based on the implicit assumption that the rabi and kharif proportions of the total irrigated and unirrigated areas respectively in each state remain the same as in the first triennium, could not capture. The dramatic increase in the share of wheat, occurring as it did after 1965-66 when the Mexican dwarf varieties arrived on the scene, was clearly produced by the enhanced profitability of wheat cultivation resulting from the higher yields of the high-yielding compared to the local varieties of wheat. Apart from the fact that the new seeds were the most successful and their spread was the fastest in the case of this crop, the hand of the new technology behind this increase is also evident from the regional differences in the expansion of wheat acreage: as would be seen in the next section, the fastest expansions in wheat area occurred in the states which registered the most considerable spread of the high-yielding varieties of wheat. That it was principally the force of the new technology rather than price can be seen from the fact that although the level of the deflated price of wheat in this period was higher than that during the first half of the 1960's, it was not much higher than that which generally prevailed during the 1950's. Further, that the expansion of wheat area was in part at the expense of gram and other pulses is reflected in the fact, shown in the next section, that the states in the vanguard of the wheat revolution - Punjab, Haryana and Uttar Pradesh - lost in terms of their share in the total gram acreage whereas the other wheat and gram producing states where the spread of the new seeds was a much weaker development increased their relative share in the total area under this crop. Thus the increase in the relative weight of wheat and decline in that of gram and other pulses in the cropping pattern were importantly produced by the same force - the force of new technology.

Unlike wheat, the improvement in the relative share of rape and mustard in the cropping pattern has its clear counterpart in the rising drift of the deflated price although in the lack of an appropriately lagged relationship between the fluctuations in the two curves one suspects the disturbing hand of weather (Figure 6).

The deflated price of rice traces a downward drift up to 1965-66 and then a revival, but no more than a revival, in the subsequent years. The hypothetical share of this crop in the total area, on the other hand, shows a perceptible increase in the second period (Figure 7). Clearly, the expansion of irrigation and cropped area provides the main explanation for the improvement in the relative weight of this crop in the cropping pattern during this period.

While the index of jute prices is available for the entire period, that for mesta is available only from 1961-62 onwards. However, for the period for which it is available it is seen to move generally in sympathy with the price of jute. We have therefore used the price of jute to examine the behavior in the cropping pattern of the relative share of the two crops considered together. Further, since jute competes almost exclusively with rice for area, we have used the jute-rice price ratio rather than the deflated price of jute even though the difference between the behavior of the two is minor. It would be seen from the accompanying graph (Figure 8) that the fortunes of these two crops in the cropping pattern have been overwhelmingly determined by the price factor.

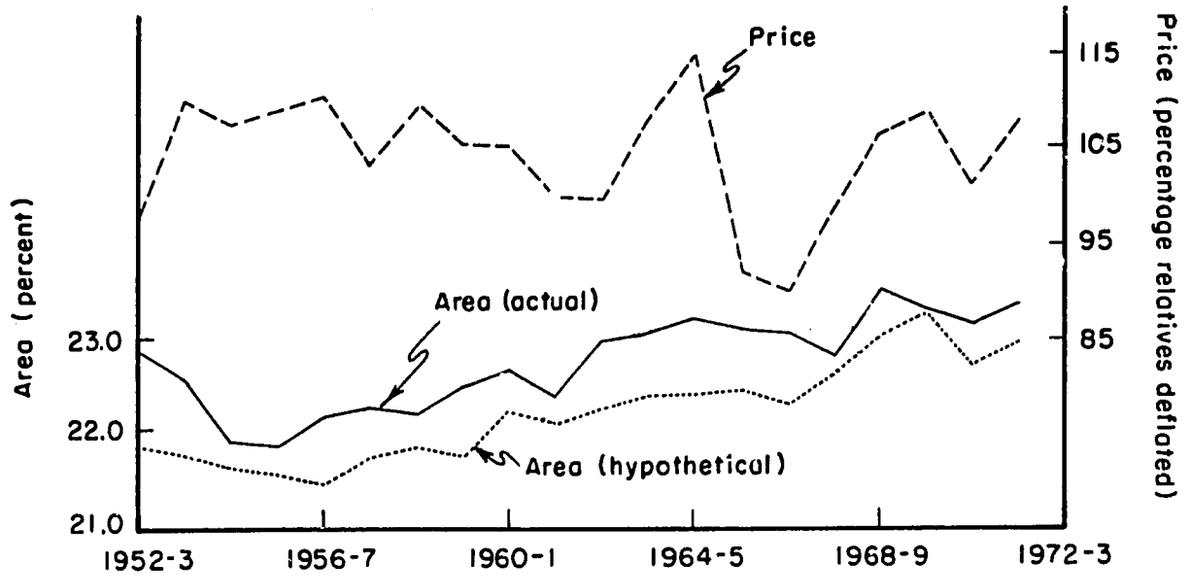


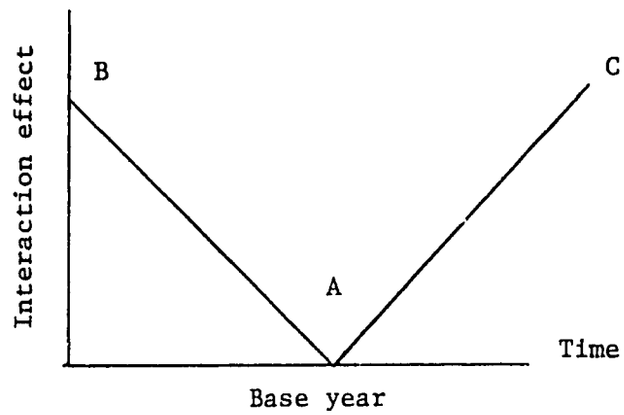
Figure 7. Rice area as percent of total cropped area and percentage relatives of rice prices deflated. Plotted against the area percentage for a year is the price for the preceding year. The time scale refers to area.

Figure 8. Jute and mesta area as percent of total cropped area and jute-rice price ratio. Plotted against the area percentage for a year is the price-ratio for the preceding year. The time scale refers to area.

The overall picture that emerges is not only similar to what has been generally revealed by the studies for India of the response of crop acreages to price but shows something more. It is similar in that while price has been found to have played a large, often leading, part in determining the share of the non-foodgrain crops in the cropping pattern, non-price factors have loomed large in the case of foodgrains except when the non-foodgrain crops have competed with these for area. It shows more in that price when confronted with the force of technological change has not been able to counter its pressure on areas under even non-foodgrain crops.

V. Locational Shifts of Areas Under Crops and Growth of Productivity

Around one-third of the growth of productivity in the first period was the result of locational shifts in the areas under individual crops. Unlike the cropping pattern effect, however, the bulk of it emanated from interactions between locational shifts and changes in the per hectare yields of individual crops in the different states. If the states which improve over time their relative share in the total area under a crop also register increases in its per hectare yield and vice-versa, locational interactions should make a positive contribution to productivity growth. While this is the case in the second period, what we find in the first period is its very opposite. What appears surprising at first sight becomes clear when we recall that changes over time in either direction are measured from the base period which, in the case of the official index, belongs somewhere in the middle rather than the beginning of the period under study. Thus, what is an increasing magnitude of the interaction effect as one moves backward from the base period (A to B in the figure below), becomes a diminishing magnitude in a forward movement from the starting year towards the base period (B to A) while it continues to be an increasing magnitude as one moves from the base period onward (A to C). In other words,



what is a symmetrical behavior of the interaction effect when measured from the base period in either direction becomes an asymmetrical behavior when change is measured, as growth of productivity is, in only one - forward - direction irrespective of the location, in time, of the base period. Thus the positive contribution of the locational interaction to the growth of productivity turns out to be the result of the vagary of the base period 1/ and imparts an upward bias to the growth rate of productivity for the first period. What is true of the locational interaction is also true of the cropping pattern interaction but the latter in the first period is too small to significantly vitiate the picture. This problem, however, arises only in the case of interactions and not pure effects. For, if a crop, for example, improves

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[1]Since, as already pointed out, it does not lie at the beginning of the period of our study.

its relative share in the total cropped area, it would increase over time the magnitude of the positive pure cropping pattern effect subsequent to the base period and in a backward movement prior to the base period increase the magnitude of the negative effect. Thus in a forward movement, both the diminishing magnitude of the negative effect and the increasing magnitude of the positive effect produce a like positive effect on the growth of productivity. It is because in the case of interactions a positive effect remains positive (and a negative effect remains negative) in both the forward and the backward movements from the base period that the problem arises.

Although short of actually shifting the base to the beginning of the period it is difficult to say what difference it would make to the growth rates of productivity for the two periods, on a qualitative plane it can yet be said that but for this problem the step-up in the growth rate for the second over that for the first period would have turned out to be more substantial than what the present index of productivity reveals.

In the overall, the real gain in productivity resulting from locational shifts, though significant in the second period, is rather small thus reflecting on the limited play of the market forces in bringing about inter-regional specialisation in the production of crops. Since a major part of the upshot derived from the locational shifts in the areas under a few crops, we focus on these to ascertain the character of the proximate forces that brought them about.

The crop which contributed most to the increase in the pure locational effect in the first period was rice. While its contribution in the second period declined, that of sugarcane and wheat increased; the former, in fact, became the most important contributor to the increase. The bulk of the positive locational interaction effect in the second period, however, emanated from the locational shifts in the area under wheat (Table 5)..

It would be seen from Figure 9 that the share of the southern states - Andhra Pradesh, Karnataka and Tamil Nadu - in the total rice acreage was increasing and that of the eastern states - Assam, Orissa and West Bengal - was declining in the first period whereas in the second, the share of the former declined while that of the eastern states registered a mild improvement. Since the per hectare yields of rice were higher in the southern compared to the eastern states, this southward shift of rice acreage in the earlier period produced an increase in the pure locational effect. And by the same token, the subsequent reversal of this picture had the effect of depressing the increase 1/ in the pure locational effect in the second period (Table 6).

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[1] arising out of the locational shifts of rice area among the remaining states.

Table 5. Locational Effect
Absolute Changes in Productivity as Measured from the Base Period (triennium ending 1961-62=0) in Rupees

Crop	Pure		Interaction	
	Average for triennium ending 1954-55	1972-73	Average for triennium ending 1954-55	1972-73
Rice	-1.38	0.20	-0.57	0.04
Jowar	0.02	0.21	0.00	-0.03
Bajra	0.10	-0.06	0.01	0.00
Maize	-0.02	-0.02	-0.04	0.05
Ragi	0.02	-0.04	0.00	0.01
Wheat	0.12	1.02	-0.02	0.24
Barley	-0.06	0.12	-0.05	0.00
Small millets	0.11	-0.06	0.01	0.00
Gram	-0.15	-0.28	0.00	0.00
Tur	0.03	0.05	-0.06	-0.03
Other pulses	-0.24	-0.41	0.03	0.01
Groundnut	0.59	0.55	0.00	0.02
Sesaucum	0.17	0.03	0.00	0.00
Rape & mustard	-0.01	-0.04	0.00	0.00
Linseed	0.01	-0.01	-0.25	0.00
Cotton (lint)	-0.71	0.27	-0.01	0.00
Jute	0.04	0.05	0.00	-0.01
Sugarcane	-0.70	1.78	0.04	-0.02

Table 6. Rice: Yield per Hectare (in quintals)
(Average for triennium ending 1961-62)

Southern States:		Eastern States:	
Andhra Pradesh	12.8	Assam	9.5
Karnataka	13.6	Orissa	9.2
Tamil Nadu	14.5	West Bengal	10.6

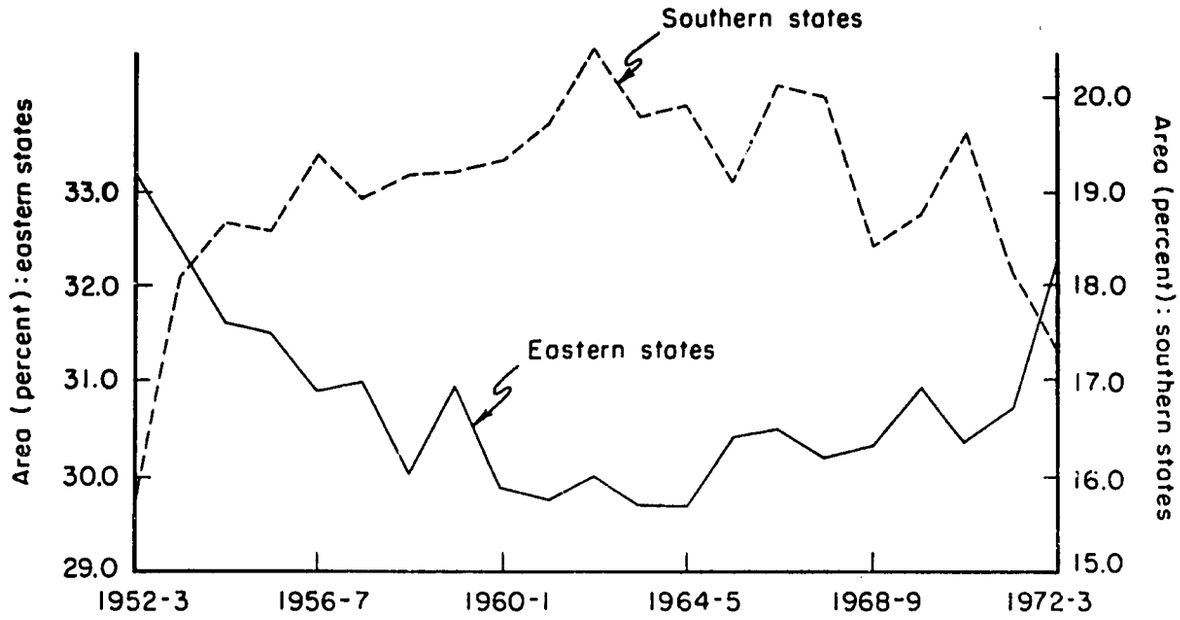

Figure 9. Percentage share of southern and eastern states in total area under rice.

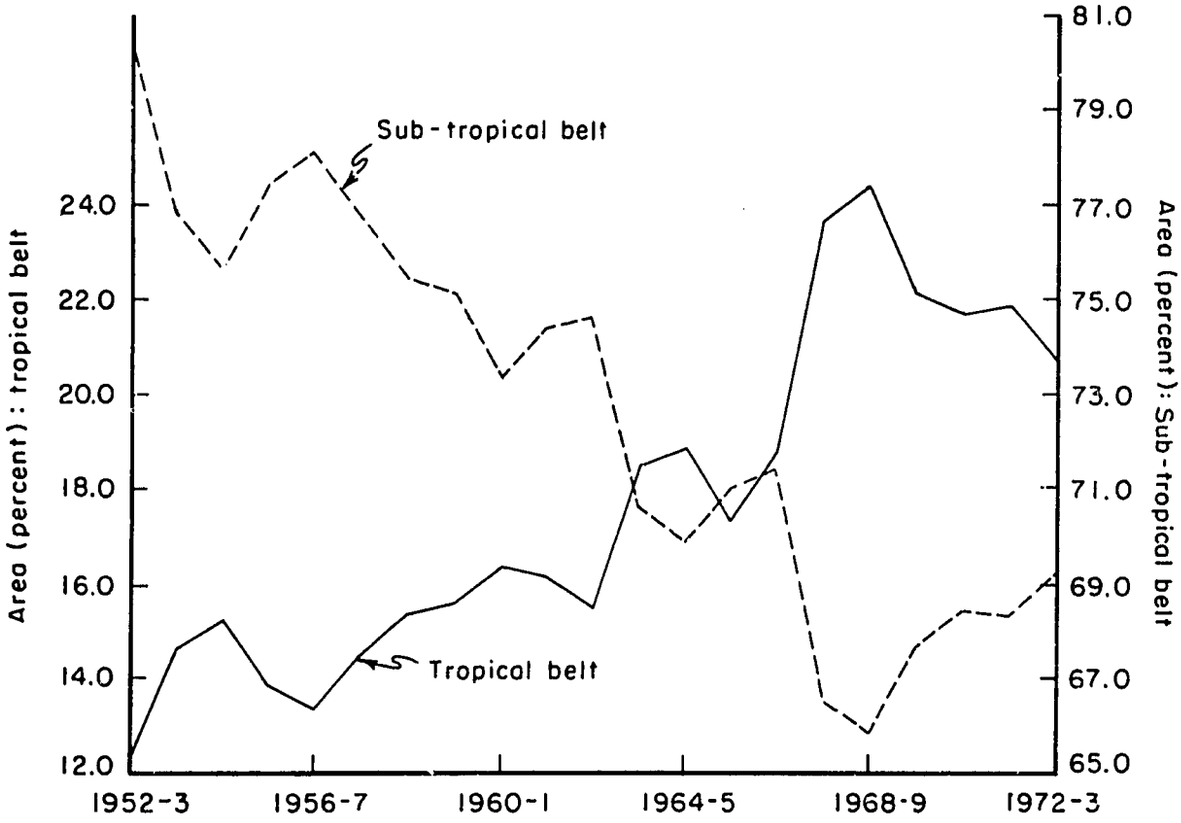

Figure 10. Percentage share of tropical and sub-tropical states in total area under sugarcane.

A good part of the explanation for this change is found in the fact that the expansion of irrigation and total cropped area in the first period was faster in the southern than in the eastern states whereas in the later period, it was the other way round. Since rice is the staple cereal in both the groups of states and in Andhra Pradesh and Tamil Nadu, it is raised as a predominantly irrigated crop. This development led to a faster expansion of rice acreage in the southern compared to the eastern states in the earlier period and to a slower one in the subsequent period. Thus the leading force behind these locational shifts in rice acreage derived from the locational differences in the faster expansions of irrigation and cropped area rather than from the market 1/ (Table 7).

Table 7. Total Cropped and Irrigated Area: Growth Rates (Compound)

	First period		Second period	
	Gross area		Gross area	
	Cropped	Irrigated	Cropped	Irrigated
Southern States	0.7	3.3	0.2	1.3
Eastern States	0.5	2.5	1.0	1.7

In the case of sugarcane, unlike rice, it was the market which played a leading part in inspiring locational shifts in area. The sub-tropical belt lost and the tropical belt gained in terms of their respective relative shares in the total sugarcane acreage (Figure 10). And the per hectare yields of this crop being much higher in the tropical than in the sub-tropical states, these locational shifts contributed to an increase in productivity in both the periods. But since this southward drift in sugarcane acreage was relatively moderate in the first and more pronounced in the second period, the gains in productivity too became more sizeable in the later period (Table 8).

In the previous section, we have referred to the fact that the stimulus of demand emanating from the growth of the sugar industry has been an important

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[1] In highlighting the play of the leading force, it is not implied that the variations over time in the spatial differences in the prices of rice and other agricultural commodities, whether produced by market imperfections or state intervention, did not bear on the locational shifts in the area under rice and other agricultural commodities; in fact, having regard to the magnitude of the task involved, a specific examination of the latter, which would constitute a sizeable study in itself, has not been attempted here.

Table 8. Sugarcane: Yield per Hectare (in terms of gur in quintals)
(Average for triennium ending 1961-62)

Tropical belt:		Sub-tropical belt:	
Andhra Pradesh	85.9	Uttar Pradesh	37.2
Maharashtra	56.6	Bihar	36.0
Karnataka	72.5	Punjab	33.9
Tamil Nadu	108.8	Haryana	36.5

factor behind the expansion of sugarcane acreage. 1/ But because of the bulky and perishable character of this crop and, therefore, the difficulties of transporting it over long distances, the location of growth in the sugar industry importantly bears on the location of expansion in sugarcane acreage. Here it is pertinent to note that the growth of the sugar industry in the tropical belt having been much faster than in the sub-tropical zone, the relative share of the former in the total installed capacity of this industry improved throughout the period (Table 9).

Table 9. Installed Capacity of the Sugar Industry
(in terms of annual sugar production)
('00,000 metric tons)

Year	All-India	Sub-tropical region		Tropical region	
1950-51	16.68	13.05	(78.23)	3.63	(21.76)
1955-56	17.77	13.39	(75.34)	4.38	(24.65)
1960-61	24.47	15.63	(63.87)	8.84	(36.13)
1965-66	32.25	18.93	(58.70)	13.32	(41.30)
1970-71	40.20	20.11	(50.02)	20.09	(49.98)
1972-73	44.56	20.72	(46.50)	23.84	(53.50)

Figures in parentheses represent percentages of the All-India installed capacity.
Source: Government of India, Ministry of Agriculture, Directorate of Sugar and Vanaspati.

[1] See p. 19

The contribution of the locational shifts in the area under wheat to the growth of productivity in the second period derived from the relative shift of wheat acreage from the states lacking in irrigational facilities - Rajasthan, Maharashtra, Gujarat and Madhya Pradesh - to those more advantageously placed in this regard - Punjab, Haryana and Uttar Pradesh (Figure 11). The per hectare yield of wheat being generally higher in the second compared to the first group of states, these locational shifts produced an increase in productivity (Table 10).

Table 10. Wheat: Yield per Hectare (in quintals)
(Average for triennium ending 1961-62)

States: Group A		States: Group B	
Punjab	11.7	Rajasthan	9.3
Haryana	12.4	Maharashtra	3.7
Uttar Pradesh	9.6	Gujarat	6.8
		Madhya Pradesh	6.8

The sudden spurt in the relative share of Punjab, Haryana and Uttar Pradesh occurred in the years of acute drought, 1965-66 and 1966-67 - an expected development, for these states were endowed with better irrigational facilities and the incidence of the drought falls most severely on unirrigated acreage. And the subsequent improvement in their share was inspired by the success of the high yielding varieties of this cereal. An important reason why these states stood in the vanguard of the wheat revolution was because they had a better base of irrigational facilities and the further spread of tubewell irrigation was supported by the program of rural electrification carried out by the governments in these states. The positive interaction effect resulting from the locational shifts of wheat acreage in the second period thus stemmed from the same force: new technology which stimulated the improvement in the relative share of these states in wheat acreage also enabled them to achieve the most substantial increases in wheat yields.

A large part of the positive contribution which the pure locational effect of wheat made to the growth of productivity in the second period was neutralized, however, by the negative effect of gram and other pulses. That the two developments were parts of the same process can be seen from the fact that the direction of the locational shifts of area under gram (as also other pulses) 1/

[1]There was a relative shift of area under other rabi pulses away from Uttar Pradesh, the only state from Group A where they are importantly grown, and in favour of Madhya Pradesh, the only state from Group B where they are important; their per hectare yields, however, are much higher in Uttar Pradesh than in Madhya Pradesh.

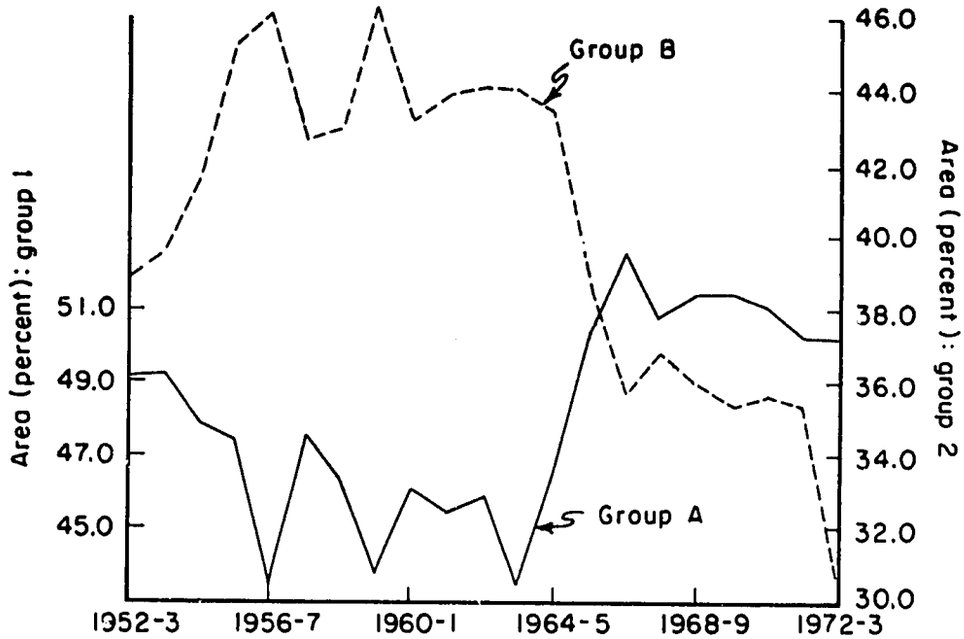

Figure 11. Percentage share of Punjab, Haryana and Uttar Pradesh (Group A) and Rajasthan, Maharashtra, Gujarat and Madhya Pradesh (Group B) in total area under wheat.

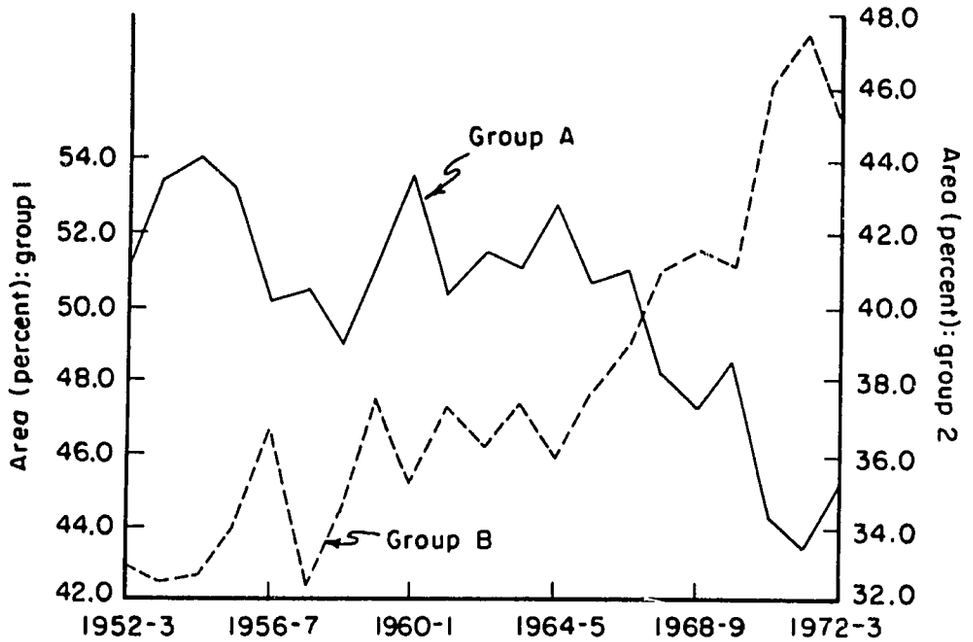

Figure 12. Percentage share of Punjab, Haryana and Uttar Pradesh (Group A) and Rajasthan, Maharashtra and Madhya Pradesh (Group B) in total area under gram.

was the very opposite of that in the case of wheat. Since the pull of wheat, enhanced by the new technology, in luring area away from pulses was the strongest in the states which were in the forefront of the wheat revolution, these states (Group A) lost in terms of their relative share in the total area under gram while the other wheat and gram producing states (Group B) 1/ improved their own (Figure 12). The per hectare yields of gram being generally higher in the former compared to the latter group of states and this being specially so in Punjab where the pull of wheat was the severest, these locational shifts produced a negative effect on productivity growth (Table 11). Thus even though, on balance, taking wheat and pulses together, the pure locational effect remained positive, it turned out to be small.

Table 11. Gram: Yield per Hectare (in quintals)
(Average for triennium ending 1961-62)

States: Group A		States: Group B	
Punjab	8.0	Maharashtra	3.4
Haryana	6.9	Rajasthan	5.8
Uttar Pradesh	6.2	Madhya Pradesh	5.9

[1]Gujarat is not an important gram producing state.

VI. Pure Increases in Per Hectare Yields and Growth of Productivity

Fertilizer use which was increasing by a meagre 30,000 metric tons per annum during the first period grew at the annual rate of over 230,000 metric tons during the second period. 1/ Consistently with the step-up in fertilizer use, the contribution of the pure increases in per hectare yields to productivity growth underwent a two and a half fold step-up from a growth rate of 0.54 percent per annum for the first to 1.33 percent per annum for the second period (Table 2). Since the latter period witnessed upward shifts in the production functions induced by the high-yielding varieties of seeds, the question arises: how far was the growth of fertilizer use in the 1960's and thereafter the result of a favorable turn in the price of fertilizer relative to the prices of agricultural commodities and how far was it inspired by the new technology? In short, what were the relative roles of the price and non-price factors in the growth of fertilizer use during this period?

Gunvant Desai, analyzing the growth of fertilizer use in India prior to the emergence of the new technology, found that of the total inter-state variation in nitrogen use per unit of cultivated area explained by the two variables, the ratio of irrigated area to total cultivated area and the price of nitrogen relative to the prices of agricultural commodities, the former accounted for a much larger proportion of the explained variation than the relative price of fertilizer. He showed further that fertilizer use accelerated with an improvement in the relative price situation but in accordance with the level of irrigation in the different states. 2/ That in the case specially of a purchased input an improvement in the price situation should help accelerate its use is what would be expected. But the fact that the level of fertilizer use during the 1960's suddenly underwent a spurt in 1966-67, the year in which the new seeds with a high response of yield to fertilizer application were released for the first time on a sizeable scale suggests that the role of technological change was far more important than that of price in promoting fertilizer use during this period.

Our indicator of technological change consists in the ratio of the area under the high-yielding varieties of seeds - for which time-series estimates are available - to the total gross cropped area. Since a great deal of the expansion of irrigation during the later 1960's was induced by the new technology, our indicator also subsumes to a large extent the play of the irrigation factor. The other independent variable we use is the index of fertilizer prices deflated by the index of agricultural commodity prices. The influence of the two factors is examined by estimating the single-equation multiple-

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[1]Estimated by fitting $Y = a + bT$ functional form to the time-series data on distribution of fertilizers by ordinary least squares.

[2]Gunvant M. Desai, Growth of Fertilizer Use in Indian Agriculture, International Agricultural Development Bulletin No. 18, New York State College of Agriculture and Life Sciences, Cornell University, pp. 78-106.

regression-analysis model 1/ for the period 1961-62 to 1971-72, the last year being the latest for which the data on total cropped area from Land Use Statistics was available. The alternative functional forms tried were:

1. $Q_f = \alpha + \beta P_f + \gamma T$

2. $\log Q_f = \alpha + \beta P_f + \gamma T$

where,

Q_f = quantity of fertilizer used (NPK in kilograms per hectare of net cropped area),

P_f = index of fertilizer prices deflated by the index of agricultural commodity prices,

and T = ratio of area under high-yielding varieties of seeds to total cropped area.

The equations were estimated by ordinary least squares. The results are presented in Table 12.

Table 12.

Equation	Dependent variable	Constant	Regression coefficients P_f	Regression coefficients T	Beta coefficients P_f	Beta coefficients T	$\bar{R}^2$	F
1.	Q_f	11.142	-8.153* (-3.255)	115.052* (14.487)	-0.197	0.875	0.97	180.2*
2.	log Q_f	3.193	-2.077* (-6.520)	11.030* (10.919)	-0.421	0.705	0.97	157.1*

Note: Figures in parentheses refer to computed t values of the regression coefficients. $\bar{R}^2$ refers to R^2 adjusted for degrees of freedom. The coefficient of correlation between the independent variables works out to only -0.50.

* Significant at 0.01 level.

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[1] Doubts may be raised about the advisability of making use of single-equation estimation procedure when the underlying model is, in principle, simultaneous in nature. Here it is pertinent to note that during the period under study, an overwhelming proportion of the total supply of fertilizer consisted of imports and the production in the public sector fertilizer factories. Since the quantities imported and the expansion of fertilizer manufacturing capacity in the public sector at any rate, were the result of autonomous decisions on the part of the Government rather than of the fertilizer price, the parameter estimates from the single-equation estimation procedure would be very largely free from the simultaneity bias.

The regression coefficients of the explanatory variables in both the equations have expected signs and the computed t values show that they are statistically significant at 0.01 level. However, a visual examination of the residuals suggested that their variance in the case of equation 1 tended to increase over time and there also appeared to be some evidence of negative auto-correlation whereas in the case of equation 2 the variance appeared to be nearly constant and the residuals more randomly distributed. Thus, on purely statistical grounds the second functional form is to be preferred.

Since the units of the two variables are different, we cannot infer from the magnitudes of the regression coefficients the relative influence exerted by the two factors on the quantity of fertilizer used. But the squares of their respective β coefficients divided by the R^2 indicate the proportions of the total explained variance which can be directly attributed to each of the independent variables while the rest cannot be directly attributed to either. From either equation, judging by the proportion of the explained variance directly attributable to each of the variables, it is clear that technological progress has exerted a far greater influence in promoting fertilizer use than the price of fertilizer relative to the prices of agricultural commodities. 1/

The limitation of the price instrument in bringing about a sizeable increase in fertilizer use is further brought out by deriving from the above equations the relative prices of fertilizer required to bring about different levels of fertilizer use when the other independent variable, i.e., technology, is held constant at its mean level (Table 13).

Table 13.

Level of Q_f	Required level of P_f when T is held constant at mean level	
	Equation 1*	Equation 2**
Mean + 1 Kg.	0.628	0.691
" + 2 Kg.	0.506	0.637
" + 4 Kg.	0.261	0.545
" + 6 Kg.	0.015	0.468
" + 8 Kg.	-	0.401
" + 10 Kg.	-	0.343
" + 20 Kg.	-	0.125
" + 25 Kg.	-	0.044

* Mean of Q_f = 8.98 ** Mean of Q_f = 7.47

[1] In this connection, it is pertinent to note that analyzing the growth of fertilizer use in Japan over the period 1883-1937, Hayami came to the conclusion that 70 percent of the increase in the commercial fertilizer input was explained by technical progress in agriculture and the remaining 30 percent by price. See, Yujiro Hayami, "Demand for Fertilizer in the Course of Japanese Agricultural Development," Journal of Farm Economics, Vol. 46, No. 4, November, 1964, p. 778.

The results based on the first equation show that an addition of 6 Kgs. per hectare to the mean level of fertilizer use at 8.98 Kgs. per hectare so as to reach an aggregate level of 15 Kgs. per hectare requires the relative price of fertilizer to drop to almost zero. According to the second equation, however, the effort to induce increases in fertilizer use requires the relative price of this input to fall much less steeply but even so, the attainment of an aggregate level of around 32 Kgs. per hectare requires the relative price of fertilizer to fall to nearly zero. It is true that the level of 32 Kgs. per hectare is much outside the range of observed variation in fertilizer use on which the equation rests and therefore the degree of confidence attaching to the derived estimate of the relative price required to reach this level of fertilizer use would be lower than for the aforementioned estimate derived from the first equation. While in view of the illustrative character of these exercises, too much need not be made of the precise numbers they disclose, the fact remains that as an instrument for extending fertilizer use, the relative price of fertilizer runs out of steam at a rather early stage. This serves to highlight that while there is an obvious limit to what the price instrument by itself can here achieve, the promotion of fertilizer use through effecting upward shifts in the production function can be a continuing process. Thus, it is clear that having regard to the ground to be traversed in India in promoting fertilizer use to the levels attained in the developed countries, the relative importance of technological progress overshadows that of price.

In this connection, the power of the stimulus that can be provided by improved technology is persuasively illustrated by the difference in fertilizer use per hectare between the Mexican and local varieties of wheat in Ferozepur district of Punjab (Table 14). It would be seen that despite the fertilizer/wheat price-ratio being higher in the case of Mexican compared to local wheat, the fertilizer used per hectare under Mexican wheat at 70 Kgs. per hectare is over two and a half times that for local wheat.

Table 14.

Fertilizer* use per hectare (in kgs.)	Price per quintal** (in Rupees)		Fertilizer/Wheat Price-ratio
	Fertilizer	Wheat	
	***		
	DESI WHEAT		
27	209.78	83.03	2.53
	MEXICAN WHEAT		
70	218.24	76.67	2.85

* NPK

** Prices refer to the unit values derived from the data on the quantity and value of fertilizer used and the quantity and value of wheat produced. Since the proportions of NPK in fertilizer used in the case of desi and Mexican wheat are different, the unit values of fertilizer too are different.

*** Refers to local.

Source: Studies in the Economics of Farm Management in Ferozepur district (Punjab), Report for the year 1969-70.

Table 15. Pure Yield Effect*
Absolute Changes in Productivity as Measured from the Base Period (triennium ending 1961-62=0) in Rupees

Crop	Average for triennium ending	
	1954-55	1972-73
Rice	-7.82	14.38
Jowar	-0.76	-1.29
Bajra	-0.21	5.86
Maize	0.42	0.89
Ragi	-0.66	0.43
Wheat	-1.97	13.69
Barley	0.48	0.90
Small millets	-0.09	-0.18
Gram	0.18	1.26
Tur	1.02	0.31
Other pulses	0.89	-0.30
Groundnut	-0.75	-0.39
Sesamum	0.42	0.43
Rape & mustard	-0.17	1.41
Linseed	2.83	0.23
Cotton lint	0.01	2.48
Jute	-0.18	-0.04
Sugarcane	-3.04	1.42
Castor seed	-0.05	0.19
Coconut	0.51	-0.81
Cotton seed	-0.31	0.99
Mesta	-0.03	-0.06
Tea	-0.93	2.16
Coffee	-0.30	0.69
Rubber	0.16	1.05
Black pepper	0.01	-0.11
Dry chillies	-0.27	0.12
Dry ginger	0.00	0.07
Turmeric	0.11	-0.09
Potatoes	0.30	1.10
Bananas	-0.24	-0.04
Tobacco	-0.30	0.66

*In the case of the first 18 crops, the locational shift effect has been separated from the pure changes in their per hectare yields, whereas in the case of the remaining 14 crops, the variations in the All-India yields are taken as they are.

Consistently with the foregoing which emphasizes the role of improved technology, the crops which account for the bulk of the contribution of the pure increases in yields to the growth of productivity in the second period are rice, wheat and bajra in the case of which the area covered by the new seeds as a proportion of their respective acreages has shown substantial increases (Tables 15 and 16).

Table 16. Area Under High-Yielding Varieties as Percentage of Area Under Crops

Year	Rice	Wheat	Jowar	Bajra	Maize
1966-67	2.52	3.91	1.05	0.48	4.10
1967-68	4.90	19.62	3.27	3.27	5.14
1968-69	7.25	30.04	3.68	6.18	6.79
1969-70	11.29	30.10	2.97	9.16	7.16
1970-71	14.51	35.86	4.62	15.74	8.01
1971-72	19.07	41.06	4.09	15.08	8.65
1972-73	22.51	50.30	5.86	21.36	10.57

While the pure yield effect of wheat and bajra in the second period compared to that in the first shows increases which are consistent with expectations, that for rice comes as a surprise in view of the fact that the growth rate for the All-India yield of this cereal decelerated from 1.64 percent per annum for the first to 1.33 percent per annum for the second period. But this is because of the clouding effect of the locational shifts in rice acreage. For, when the locational shift effect is removed - and this crop is affected the most by the asymmetry between the locational interaction effect in the two periods discussed in Section 5 - the growth rate for the pure increases in its per hectare yield is seen to accelerate by about 50 percent, from 0.75 percent per annum for the first to 1.14 percent per annum for the second period. This finding appears to us to be significant for it shows that the impact of the new seeds on the growth of rice yields is larger than what has so far appeared to have been the case thus resolving the dilemma arising out of the deceleration in the growth rate of All-India yield of rice in the face of a sizeable increase in the proportion of rice acreage covered by the new seeds.

VII. Summary and Conclusions

We have argued that the base period of the index of productivity being what it is, it imparts an asymmetry to the manner in which the interaction effects bear on the growth of productivity in the two periods, and this asymmetry imparts an upward bias to the growth rate of productivity for the first period. We have thus shown that the substantive step-up in the growth rate of productivity for the 1960's and thereafter over that for the 1950's has been significantly larger than what the present index of productivity reveals. While this brightens the prospects for what can be achieved in the coming years, the fact remains that the achievement so far has been far short of requirements.

Since the central question here pertains to the instruments that need to be wielded to ensure that the achievement measures up to the requirements, we have sought to examine the role of price and non-price factors in productivity growth. Consistently with the findings of the studies for India of the response of individual crop areas to price, relative prices have shown themselves to be an effective determinant of the share of non-foodgrain crops in total cropped area, whereas non-price factors have been found to loom large in conditioning the relative area shares of foodgrain crops. Even more important, when price has had to contend with the force of technological change, it has failed to counter the competitive pull of the crop experiencing technological change on the area under its competing crops. The play of the market, likewise, in increasing productivity through the inter-regional specialization in the production of crops has been found to be rather weak unless aided by other factors such as an appropriate locational shift of the processing industry in the case of sugarcane, and the expansion of tubewell irrigation, facilitated by the program of rural electrification, which sustained technological progress in the case of wheat.

Since a priori price would be expected to be a significant force in promoting the use-intensity of purchased inputs to bring about what we have christened here the pure increases in per hectare yields, we have examined the relative roles of price and technological change in accelerating the use of fertilizer - the leading input for increasing yield. While few would deny the pertinence of the crop-fertilizer price-ratio in influencing fertilizer application to areas under crops and therefore the need to maintain it within a favorable range, the crucial question here is whether having regard to the magnitude of the step-up required in fertilizer use, a major reliance can be placed on the price instrument to deliver the required increase. In this connection, it is pertinent to note that a leading factor behind the failure to achieve the targets of agricultural production in the Third and Fourth Plan periods has been the shortfall in achievement compared to the targets in respect to fertilizer use - the actual achievement having been half of the targeted increase in both the periods. 1/ Given the magnitude of the task involved in

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[1]See Government of India, Ministry of Agriculture, Directorate of Economics and Statistics, Indian Agriculture in Brief, Eleventh Edition, p. 155; and Government of India, Ministry of Agriculture, Agricultural Prices Commission, Report on Price Policy for Kharif Cereals for the 1974-75 Season (mimeo), pp. 5-6.

achieving such targeted increases, the moral of our finding that technological progress is an instrument of far greater consequence than the relative price of fertilizer in accelerating the use of this input becomes obvious. It underscores the fact that an over-simplistic and therefore excessive preoccupation with price can do more harm than good by distracting attention from the harder but more important tasks which belong in the non-price world of achieving technological breakthroughs and relaxing such real constraints as stand in the way of their becoming a reality on the farmers' fields.

Table A-1. Pure Cropping Pattern Effect

Absolute Changes in Productivity as Measured from the Base Period (triennium ending 1961-62=0) in Rupees

Year	Rice	Jowar	Bajra	Maize	Ragi	Wheat	Barley	Small Millets	Gram	Tur	Other Pulses	Ground-nut	Sesamum	Rape & Mustard	Linseed	Castor Seed
1952-52	1.952	2.583	1.094	-0.470	0.168	-4.295	0.807	0.633	-1.870	0.650	-0.206	-2.959	0.601	-1.120	-0.319	0.133
1953-54	0.325	1.571	1.821	-0.348	0.086	-3.582	0.990	0.910	-1.410	0.374	0.339	-5.534	0.666	-1.080	-0.375	0.110
1954-55	-3.305	0.920	0.948	-0.706	-0.051	-2.492	0.691	0.816	0.416	0.313	-0.803	-1.704	0.694	-0.709	-0.420	0.114
1955-56	-3.682	-0.197	0.652	-1.030	-0.164	-0.595	0.525	0.465	0.828	-0.050	-0.262	-3.391	0.243	-0.603	-0.289	0.117
1956-57	-1.801	-1.353	0.497	-0.967	-0.261	1.895	0.655	0.154	0.549	-0.076	-0.168	-2.332	0.088	-0.685	-0.149	0.108
1957-58	-1.467	0.001	0.446	0.940	0.029	-2.290	-0.148	0.080	0.604	0.067	-0.383	0.351	0.007	-0.946	-0.545	-0.013
1958-59	-1.868	0.147	0.379	-0.168	0.129	-1.070	0.116	0.185	0.741	0.143	-0.092	-0.703	0.106	-1.026	-0.280	0.081
1959-60	-0.112	-0.263	-0.276	-0.056	0.059	0.524	0.201	0.157	1.020	0.035	0.131	-0.247	-0.028	-0.094	0.078	0.015
1960-61	0.612	0.497	0.333	0.040	0.037	-0.610	-0.121	0.001	-0.540	0.028	-0.096	-0.248	-0.001	-0.169	-0.106	-0.011
1961-62	-0.488	-0.229	-0.056	0.016	-0.094	0.085	-0.078	-0.154	-0.465	-0.061	-0.034	0.482	0.028	0.256	0.027	-0.004
1962-63	2.676	-0.112	-0.340	0.247	-0.162	0.027	-0.595	-0.235	-1.032	-0.067	0.257	1.516	0.330	0.152	-0.047	-0.021
1963-64	2.877	-0.189	-0.241	0.116	-0.194	-0.243	-1.019	-0.349	-0.828	0.045	-0.015	0.377	0.181	-0.020	0.035	-0.008
1964-65	3.771	-0.782	0.232	0.087	0.020	-0.722	-1.225	-0.431	-1.641	0.104	-0.036	1.514	0.229	-0.357	0.058	-0.052
1965-66	3.282	-0.728	0.569	0.649	0.301	-1.919	-1.189	-0.349	-2.555	0.176	-0.026	2.912	0.314	-0.212	-0.199	-0.076
1966-67	3.050	-0.202	0.835	1.226	-0.414	-1.197	-0.850	-0.319	-2.522	0.131	-0.448	1.877	0.624	0.003	0.408	-0.079
1967-68	1.720	-0.685	0.854	1.755	-0.652	2.227	-0.149	-0.460	-2.660	0.188	-0.762	1.686	0.359	0.207	-0.212	-0.060
1968-69	5.715	0.004	0.422	2.181	-0.681	4.687	-1.092	-0.293	-4.066	0.021	-0.683	0.744	0.168	-0.430	-0.259	-0.095
1969-70	4.696	-0.696	0.508	2.163	0.209	5.364	-1.204	-0.392	-3.457	0.146	-0.960	0.325	-0.011	0.002	-0.205	-0.098
1970-71	3.054	-2.181	0.764	2.070	-0.394	8.541	-1.576	-0.380	-3.411	0.089	-0.675	0.730	0.096	0.250	-0.132	-0.067
1971-72	4.752	-2.737	-0.061	1.787	-0.457	0.655	-1.717	-0.575	-3.258	-0.432	-0.742	1.325	0.067	0.844	0.027	0.053
1972-73	4.249	-4.176	0.293	2.359	-0.526	4.106	1.623	0.656	-4.151	-0.278	-0.952	0.447	0.007	0.701	-0.195	-0.081

Table A-1 (continued)

Year	Coconut	Cotton Seed	Cotton Lint	Jute	Mesta	Tea	Coffee	Rubber	Pepper	Chillies	Ginger	Tumeric	Potato	Banana	Sugar cane	Tobacco
1952-53	0.330	-0.130	-0.390	0.700	-0.349	1.071	-0.056	-0.160	-0.024	-0.433	0.018	0.091	-0.914	-0.293	4.244	0.140
1953-54	0.077	0.016	0.049	-1.278	-0.424	0.415	-0.107	-0.173	-0.039	-0.316	-0.033	0.134	-1.092	-0.392	-0.126	-0.053
1954-55	-0.219	0.277	0.831	-1.280	-0.469	0.316	-0.099	-0.173	-0.024	0.556	-0.020	0.191	-1.012	-0.252	-7.483	-0.405
1955-56	-0.332	0.455	1.363	-0.006	-0.295	0.060	-0.069	-0.176	-0.031	0.061	-0.016	0.136	-0.923	0.029	-4.997	0.271
1956-57	-0.289	0.383	1.147	0.413	-0.069	-0.027	-0.139	-0.155	-0.035	-0.012	-0.017	0.256	-0.874	-0.127	-2.486	0.339
1957-58	-0.191	0.389	1.166	-0.030	-0.021	0.159	-0.092	-0.115	-0.013	0.255	-0.010	0.115	-0.399	0.007	-2.120	-0.391
1958-59	-0.156	0.237	0.710	0.014	0.143	-0.120	-0.040	-0.042	-0.027	-0.465	-0.027	0.000	-0.305	-0.112	-4.569	-0.282
1959-60	0.039	-0.130	-0.389	-0.345	-0.117	0.111	-0.018	-0.019	-0.025	-0.156	-0.007	-0.034	-0.018	0.036	-2.253	0.040
1960-61	0.036	0.020	0.059	-0.704	-0.184	0.077	0.004	-0.001	0.019	0.372	-0.001	-0.036	0.133	0.004	1.247	-0.059
1961-62	-0.073	0.107	0.320	1.022	0.293	-0.183	0.014	0.019	0.006	-0.211	0.008	0.068	-0.112	-0.039	0.974	0.019
1962-63	0.569	-0.031	-0.092	0.559	0.189	-0.157	0.036	0.033	-0.001	-0.050	0.008	0.170	0.472	0.268	-1.805	-0.148
1963-64	0.558	0.208	0.623	0.689	0.207	-0.143	0.059	0.057	-0.002	0.888	0.021	0.228	0.488	0.501	-1.763	0.260
1964-65	0.917	0.234	0.700	0.479	0.085	-0.135	0.081	-0.057	-0.002	0.548	0.019	0.379	0.604	0.557	2.312	-0.195
1965-66	1.419	0.129	0.388	0.049	0.060	0.236	0.115	0.078	0.005	-0.015	0.022	0.374	1.362	0.912	6.045	-0.422
1966-67	1.534	0.083	0.249	0.321	-0.036	0.376	0.112	0.123	0.100	0.764	0.023	0.228	1.313	0.890	-0.616	0.148
1967-68	1.459	-0.009	-0.027	0.614	-0.085	0.008	0.065	0.133	0.079	1.054	0.004	0.133	1.398	0.691	-4.964	-0.064
1968-69	2.153	-0.141	-0.423	-1.504	-0.202	0.272	0.108	0.160	0.084	0.107	0.000	0.234	1.783	0.994	1.469	0.198
1969-70	2.307	-0.176	-0.527	-0.124	-0.092	0.048	0.078	0.172	0.064	0.115	0.003	0.339	0.950	1.071	3.256	0.043
1970-71	2.357	-0.262	-0.784	-0.271	-0.074	0.006	0.112	0.185	0.060	0.901	0.008	0.502	1.067	0.945	1.422	0.109
1971-72	2.675	-0.149	-0.446	0.154	-0.177	0.149	0.142	0.203	0.059	0.688	0.027	0.480	1.217	0.949	-1.127	0.256
1972-73	3.259	-0.031	-0.094	-0.319	-0.161	0.645	0.251	0.248	0.083	0.310	0.021	0.381	1.929	1.058	1.293	0.203

Table A-2. Cropping Pattern Interation Effect

Absolute Changes in Productivity as Measured from the Base Period (triennium ending 1961-62=0) in Rupees

Year	Rice	Jowar	Bajra	Maize	Ragi	Wheat	Barley	Small Millets	Gram	Tury	Other Pulses	Ground-nut	Sesamum	Rape & Mustard	Linseed	Castor Seed
1952-53	-0.359	-0.336	-0.108	-0.006	-0.048	0.322	0.018	-0.035	0.058	0.033	0.000	0.506	0.089	0.031	-0.051	-0.021
1953-54	-0.014	-0.090	0.244	0.001	-0.003	0.337	-0.054	0.072	-0.018	0.055	0.004	-0.558	0.176	0.077	-0.066	-0.018
1954-55	0.434	0.078	-0.027	-0.006	0.004	0.073	-0.009	0.078	0.007	0.019	-0.069	-0.068	0.217	-0.010	-0.090	-0.003
1955-56	0.313	-0.040	-0.014	0.103	-0.003	0.085	-0.032	-0.019	-0.071	-0.010	-0.011	-0.072	0.040	0.119	-0.047	-0.006
1956-57	0.104	0.097	-0.089	-0.045	-0.005	-0.304	-0.047	-0.006	0.035	-0.022	0.016	-0.170	0.014	0.013	0.002	-0.005
1957-58	0.253	0.000	0.018	-0.131	-0.001	0.424	0.023	-0.008	-0.099	-0.006	0.041	-0.001	0.000	0.073	0.077	0.002
1958-59	0.053	0.005	0.033	0.010	-0.001	0.062	-0.009	0.011	0.112	0.000	-0.001	-0.079	0.042	-0.018	-0.057	-0.010
1959-60	0.006	0.001	-0.017	0.000	0.003	-0.041	-0.018	-0.002	-0.102	0.000	0.001	0.004	-0.002	0.012	-0.001	0.000
1960-61	0.013	0.052	-0.027	0.000	-0.002	-0.010	0.000	0.000	-0.061	0.006	0.001	-0.009	0.000	-0.020	0.003	0.000
1961-62	-0.015	0.024	-0.002	0.000	-0.001	0.005	-0.007	-0.004	0.001	0.013	0.000	-0.009	0.000	0.003	0.001	0.000
1962-63	-0.157	-0.010	-0.053	0.014	-0.008	-0.001	0.048	0.017	0.039	0.006	-0.005	-0.051	0.062	-0.001	0.000	0.001
1963-64	0.117	-0.006	-0.029	0.007	-0.008	0.031	0.160	-0.021	0.171	-0.010	0.001	0.026	0.022	0.006	-0.006	0.001
1964-65	0.323	-0.081	0.052	0.006	-0.000	-0.065	-0.084	-0.022	-0.122	0.003	-0.001	0.241	0.046	-0.075	0.004	-0.001
1965-66	-0.433	0.086	0.002	0.043	-0.112	0.024	-0.031	0.059	0.333	-0.008	0.003	-0.615	0.012	-0.014	0.030	0.012
1966-67	0.399	-0.010	0.141	0.029	0.044	-0.072	0.047	0.067	0.638	-0.049	0.074	-0.261	-0.053	-0.000	0.094	-0.014
1967-68	0.067	-0.083	0.253	0.336	-0.028	0.706	-0.027	-0.006	-0.515	-0.015	-0.006	0.136	0.011	0.032	-0.019	-0.011
1968-69	0.473	0.000	0.004	0.127	0.045	1.928	0.001	0.022	-0.004	0.000	0.005	-0.052	0.012	-0.052	0.037	-0.025
1969-70	0.376	-0.052	0.186	0.058	-0.007	2.379	-0.140	0.043	-0.625	-0.004	0.002	0.008	-0.002	0.000	-0.031	-0.030
1970-71	0.458	0.089	0.757	0.740	-0.042	4.788	-0.376	-0.005	-0.323	0.000	-0.039	0.137	0.040	0.105	-0.014	-0.022
1971-72	0.704	0.147	-0.027	-0.081	-0.071	6.907	-0.332	0.053	-0.195	-0.004	0.015	0.229	0.010	-0.045	0.004	-0.024
1972-73	0.339	0.442	0.011	0.354	-0.032	7.016	-0.162	0.092	-0.261	-0.015	0.200	-0.084	0.000	0.214	-0.023	-0.036

Table A-2 (continued)

Year	Coconut	Cotton Seed	Cotton Lint	Jute	Mesta	Tea	Coffee	Rubber	Pepper	Chillies	Ginger	Turmeric	Potato	Banana	Sugar-cane	Tobacco
1952-53	0.025	0.019	0.056	-0.007	0.056	-0.039	0.021	-0.035	0.001	0.027	-0.004	0.014	-0.120	0.011	0.821	-0.016
1953-54	0.007	-0.001	-0.001	0.019	0.068	-0.065	0.028	-0.089	-0.001	0.023	-0.006	0.018	-0 110	0.034	1.303	0.002
1954-55	-0.015	-0.013	-0.022	0.099	-0.108	-0.024	0.025	-0.076	-0.004	-0.007	-0.001	0.042	0.041	0.023	0.126	0.014
1955-56	-0.005	-0.074	-0.198	0.000	-0.061	-0.006	0.007	-0.111	-0.004	-0.002	-0.002	0.059	0.035	-0.002	0.549	-0.009
1956-57	-0.011	-0.002	0.017	-0.051	-0.013	0.001	-0.002	-0.085	-0.004	0.000	-0.001	0.090	0.111	0.008	0.203	-0.016
1957-58	-0.008	0.001	0.003	0.003	0.000	-0.008	-0.008	-0.026	-0.001	-0.020	0.000	0.029	0.048	0.000	0.636	0.049
1958-59	-0.005	-0.002	-0.006	0.001	0.016	0.003	-0.002	-0.004	-0.001	0.020	0.000	0.000	0.006	0.001	0.011	-0.027
1959-60	0.001	0.024	0.072	0.003	0.006	-0.003	-0.002	0.000	0.000	0.005	0.000	-0.003	-0.001	-0.001	0.039	-0.003
1960-61	0.000	0.004	0.011	0.016	0.003	-0.003	0.000	0.000	0.000	0.007	0.000	-0.004	0.001	0.000	0.057	0.000
1961-62	0.003	-0.002	-0.005	0.023	0.013	-0.011	-0.001	0.000	0.000	-0.002	0.000	-0.010	0.008	0.000	-0.029	0.001
1962-63	-0.012	-0.005	-0.015	-0.025	0.013	-0.005	-0.003	0.004	0.000	-0.003	0.000	-0.017	0.033	-0.002	0.120	-0.018
1963-64	-0.044	0.027	0.087	0.028	0.030	-0.004	-0.002	0.012	0.000	0.038	0.000	-0.016	-0.088	-0.001	-0.094	0.022
1964-65	-0.069	0.038	0.123	0.032	0.004	-0.012	-0.002	0.025	0.000	0.032	0.000	-0.006	0.062	0.002	0.142	-0.033
1965-66	-0.161	-0.002	-0.001	-0.006	-0.006	0.015	0.036	0.048	-0.001	0.001	0.001	-0.041	0.158	0.134	-0.021	-0.014
1966-67	-0.146	0.010	0.025	0.000	0.003	0.030	0.073	0.294	-0.020	-0.058	0.000	-0.022	-0.031	0.185	0.053	0.016
1967-68	-0.152	-0.002	-0.005	0.042	0.003	0.001	0.012	0.305	-0.018	0.015	0.000	-0.006	0.151	0.096	-0.288	-0.010
1968-69	-0.273	-0.026	-0.073	0.260	0.044	0.037	0.053	0.372	-0.019	-0.004	0.000	-0.042	0.326	0.051	0.178	0.018
1969-70	-0.271	-0.033	-0.094	-0.012	0.014	0.005	0.023	0.416	-0.016	-0.009	0.000	-0.028	0.089	0.022	0.357	0.001
1970-71	-0.227	-0.010	-0.020	0.005	0.006	0.001	0.129	0.468	-0.013	0.053	0.004	-0.060	0.328	-0.045	0.140	0.008
1971-72	-0.325	-0.071	-0.205	0.006	0.011	0.030	0.045	0.535	-0.012	0.032	0.015	-0.067	0.348	-0.055	-0.066	0.056
1972-73	-0.510	-0.008	-0.022	-0.008	0.004	0.159	0.160	0.658	-0.018	-0.012	0.012	-0.065	0.214	0.077	0.165	0.024

Table A-3. Pure Locational Effect

Absolute Changes in Productivity as Measured from the Base Period (triennium ending 1961-62=0) in Rupees

Year	Rice	Jowar	Bajra	Maize	Ragi	Wheat	Barley	Small Millets	Gram	Tur	Other Pulses	Ground-nut	Sesamum	Rape & Mustard	Linseed	Cotton Lint	Jute	Sugar Cane
1952-53	-2.424	0.064	-0.077	0.056	-0.077	0.203	-0.061	0.117	-0.279	0.001	-0.190	0.975	0.161	0.008	0.018	-0.455	-0.023	-1.396
1953-54	-1.033	0.029	0.055	-0.063	0.051	0.222	-0.142	0.135	-0.135	-0.107	0.081	0.357	0.162	0.000	0.009	-0.826	0.052	-0.580
1954-55	-0.692	-0.036	0.333	-0.059	0.072	0.128	0.018	0.092	-0.040	0.010	-0.601	0.438	0.184	-0.032	-0.006	-0.850	0.091	-0.110
1955-56	-0.805	-0.015	0.512	-0.033	-0.055	0.165	0.039	0.142	-0.048	0.055	-0.254	0.559	0.175	-0.043	-0.006	-1.274	0.027	-0.580
1956-57	-0.167	0.050	0.148	-0.082	0.059	-0.184	0.072	0.017	-0.109	-0.022	-0.452	0.503	0.043	-0.060	-0.008	-0.401	-0.193	-0.794
1957-58	-0.277	0.017	0.057	-0.098	0.003	0.232	-0.003	-0.016	-0.288	-0.033	-0.006	0.342	0.060	-0.084	-0.022	0.145	-0.059	-0.458
1958-59	-0.456	-0.031	0.103	-0.027	-0.008	0.210	-0.004	-0.042	-0.246	-0.015	0.021	0.217	0.079	-0.070	-0.001	0.084	0.014	-0.282
1959-60	-0.298	-0.054	0.038	-0.017	-0.009	-0.171	-0.004	-0.042	0.014	-0.002	-0.125	0.007	-0.014	0.009	0.000	-0.016	0.015	-0.224
1960-61	0.001	0.072	-0.031	0.018	0.019	0.048	-0.029	0.012	0.057	0.011	0.079	0.045	0.022	0.005	0.002	-0.010	0.025	0.186
1961-62	0.289	-0.021	-0.005	-0.002	-0.010	0.123	0.031	0.032	-0.070	-0.009	0.046	-0.048	-0.009	-0.013	-0.002	0.024	-0.028	0.012
1962-63	0.442	-0.005	0.122	0.029	-0.002	0.198	-0.025	-0.060	-0.026	0.025	0.187	-0.014	-0.016	-0.035	-0.002	0.113	-0.010	-0.146
1963-64	0.326	-0.064	0.225	0.019	0.017	-0.282	-0.142	0.003	-0.049	0.120	0.026	0.213	0.293	-0.039	-0.003	0.368	0.000	1.036
1964-65	0.422	-0.048	0.035	0.004	0.004	0.312	-0.012	0.015	-0.021	0.123	-0.041	0.093	-0.035	-0.012	-0.005	0.198	0.021	1.322
1965-66	0.219	0.022	-0.040	-0.017	0.027	0.643	-0.075	-0.009	-0.121	0.124	-0.056	0.226	-0.039	-0.005	-0.007	0.244	-0.004	0.902
1966-67	0.902	0.103	0.032	-0.001	0.017	0.849	-0.098	-0.068	-0.094	0.191	-0.044	0.310	-0.058	0.010	-0.026	0.250	0.003	0.884
1967-68	0.623	0.155	0.221	-0.022	-0.026	0.821	-0.107	-0.145	-0.189	0.110	-0.300	0.334	-0.040	0.020	-0.020	0.187	0.040	2.446
1968-69	0.080	0.236	0.148	-0.038	-0.036	0.935	0.004	-0.042	-0.404	0.143	-0.127	0.207	0.013	0.036	-0.021	0.044	0.052	2.980
1969-70	0.304	0.082	0.209	0.004	-0.007	1.042	0.047	-0.022	-0.234	0.047	-0.231	0.510	0.075	0.013	-0.023	0.089	0.055	1.994
1970-71	0.669	0.092	0.052	0.000	-0.044	1.100	0.138	-0.046	-0.303	0.043	-0.482	0.545	0.032	-0.012	-0.019	0.021	0.046	1.802
1971-72	-0.113	0.242	-0.010	-0.037	-0.034	0.971	0.139	-0.092	-0.330	-0.013	-0.441	0.536	0.017	-0.049	-0.016	0.068	0.066	1.896
1972-73	0.058	0.309	-0.213	-0.013	-0.048	1.001	0.068	-0.038	-0.204	0.120	-0.315	0.556	0.045	-0.046	-0.008	0.728	0.035	1.632

Table A-4.

Locational Interaction Effect

Absolute Changes in Productivity as Measured from the Base Period (triennium ending 1961-62-0) in Rupees

Year	Rice	Jowar	Bajra	Maize	Ragi	Wheat	Barley	Small Millets	Gram	Tur	Other Pulses	Ground-nut	Sesamum	Rape & Mustard	Linseed	Cotton Lint	Jute	Sugar Cane
1952-53	-6.460	0.029	0.145	-0.488	0.131	-0.421	-1.385	0.081	-0.169	-1.437	-0.066	0.510	-0.036	-0.010	-3.637	0.198	-0.007	0.892
1953-54	-6 677	0.080	-0.040	-0.159	-0.160	-0.100	-0.120	0.151	0.010	-0.234	-0.403	-0.884	0.034	0.020	-0.684	-0.167	-0.042	0.122
1954-55	-4.029	-0.048	0.275	-0.404	0.021	-0.084	-0.001	0.152	0.040	-0.099	-0.507	0.285	-0.084	0.015	-3.172	-0.212	-0.038	0.042
1955-56	-2.087	0.002	-0.171	-0.244	-0.058	-0.501	-0.016	0.064	-0.012	-0.046	-0.004	0.818	0.036	0.132	-2.741	-2.568	-0.046	0.256
1956-57	-0.188	-0.014	0.029	0.046	0.004	0.067	0.007	0.002	-0.046	-1.711	0.137	0.916	-0.010	0.076	-1.406	-0.248	0.370	0.290
1957-58	-0.503	0.031	0.065	-0.344	0.006	-0.052	0.024	-0.004	-0.196	0.001	0.071	0.136	0.004	0.034	-0.656	-0.095	0.037	0.038
1958-59	-0.036	0.027	0.040	-0.022	0.009	-0.090	-0.002	0.007	-0.528	0.000	-0.002	-0.299	-0.074	-0.037	-1.678	-0.036	-0.008	0.092
1959-60	-0.132	0.009	0.002	0.031	-0.007	-0.013	0.004	0.003	-0.014	0.003	0.004	0.014	-0.021	0.002	-0.001	0.035	-0.009	0.056
1960-61	0.016	0.041	-0.027	0.009	-0.002	-0.013	0.001	0.000	0.023	0.004	0.009	-0.003	0.017	0.006	-0.002	-0.010	-0.006	0.032
1961-62	-0.146	0.006	0.013	0.002	-0.004	-0.008	-0.002	0.006	-0.003	0.020	-0.002	-0.034	-0.007	0.009	0.002	-0.043	-0.002	-0.012
1962-63	-4.790	0.035	-0.018	-0.047	-0.004	-0.023	0.007	0.017	-0.005	-0.038	0.055	0.101	0.007	0.073	-0.006	0.000	0.043	-0.027
1963-64	-0.153	-0.006	0.000	0.006	-0.009	-0.379	0.151	-0.007	0.048	-0.086	0.020	0.067	-3.022	-0.033	-0.011	-0.094	0.002	-0.206
1964-65	-0.100	0.095	-0.250	0.070	-0.023	0.092	0.015	-0.015	0.044	-0.168	0.199	0.053	0.009	-0.020	0.015	-0.044	0.063	-0.495
1965-66	0.030	0.048	-0.134	0.024	-0.223	0.363	0.087	-0.009	0.376	-0.169	0.029	0.236	-0.003	0.001	0.033	-0.055	0.007	-0.416
1966-67	1.180	-0.128	-0.043	0.018	0.073	0.764	0.191	0.011	-0.128	-0.222	0.147	0.323	-0.046	0.024	-0.067	0.021	0.023	-0.018
1967-68	0.029	0.169	-0.180	-0.003	0.051	0.864	0.114	-0.419	-0.288	-0.110	-0.207	0.062	-0.043	0.019	-0.010	-0.091	0.072	-0.184
1968-69	0.249	0.114	-0.088	0.080	0.156	1.685	0.132	0.071	-0.042	-0.022	-0.133	0.054	0.024	-0.006	-0.028	-0.066	0.044	-0.673
1969-70	0.162	0.017	-0.026	0.123	0.067	1.810	0.060	0.000	-0.220	-0.250	-0.063	0.011	0.057	-0.026	-0.075	-0.092	0.055	-0.670
1970-71	0.324	-0.122	-0.209	0.178	0.048	2.231	0.024	-0.095	-0.034	-0.225	0.114	-0.777	-0.075	0.006	0.000	-0.247	-0.009	-0.206
1971-72	0.177	-0.622	0.194	0.651	0.126	2.478	-0.043	-0.044	-0.125	-0.264	0.101	-0.101	-0.022	-0.035	-0.011	0.262	0.154	-0.069
1972-73	0.707	-0.262	0.056	0.552	0.244	2.470	0.018	0.050	0.238	-0.309	0.140	1.340	-0.018	0.037	0.014	0.120	0.041	-0.255

Table A-5a.

Pure Yield Effect*

Absolute Changes in Productivity as Measured from the Base Period (triennium ending 1961-62=0) in Rupees

Year	Rice	Jowar	Bajra	Maize	Ragi	Wheat	Barley	Small Millets	Gram	Tur	Other Pulses	Ground-nut	Sesamum	Rape & Mustard	Linseed	Cotton Lint	Jute	Sugar Cane
1952-53	-14.145	-2.843	-0.964	0.540	-1.447	-2.035	1.574	-0.400	0.014	1.669	0.241	-4.698	0.215	-0.166	3.910	-1.434	-0.015	-5.291
1953-54	2.430	-1.316	1.205	0.198	-0.062	-2.949	-0.047	0.006	0.304	1.017	0.440	2.423	0.415	-0.459	0.997	0.713	-0.083	-3.395
1954-55	-11.754	1.871	-0.865	0.532	-0.457	-0.931	-0.090	0.111	0.217	0.365	1.998	0.028	0.621	0.101	3.571	0.754	-0.423	-0.438
1955-56	- 7.759	-4.271	-0.540	-0.587	0.193	-3.977	-0.367	-0.359	-1.124	0.933	0.703	-0.976	0.172	-1.296	3.044	2.148	-0.249	-2.963
1956-57	- 6.873	-1.607	-1.814	0.440	0.034	-4.714	-0.491	-0.171	1.034	3.039	-0.654	-0.051	0.323	-0.136	1.384	0.823	-0.770	-1.941
1957-58	-20.865	0.503	0.251	-0.768	-0.185	-5.754	-0.898	-0.360	-1.797	-0.389	-1.181	-0.510	0.040	-0.421	0.419	-0.023	-0.491	-2.165
1958-59	- 3.071	0.728	0.656	-0.464	-0.027	-1.869	-0.439	0.252	2.880	0.019	0.105	2.135	0.907	0.212	2.051	-0.149	0.277	0.117
1959-60	- 6.225	-0.021	0.507	0.021	0.242	-2.165	-0.499	-0.009	1.387	-0.024	0.184	-0.329	0.210	-0.805	-2.017	-2.170	-0.054	-0.354
1960-61	2.561	2.115	-0.693	-0.107	-0.284	0.445	0.012	-0.057	1.490	0.953	-0.145	0.626	-0.255	0.700	-0.044	2.280	-0.126	1.145
1961-62	3.808	-2.170	0.236	0.043	0.055	1.745	0.495	0.058	0.046	-0.950	-0.052	-0.323	0.057	0.086	0.057	-0.169	0.140	-0.886
1962-63	- 3.016	1.845	1.319	0.499	0.241	-1.765	-0.441	-0.221	-0.490	-0.406	-0.448	-0.725	0.446	-0.067	0.001	1.771	-0.246	-1.822
1963-64	4.902	0.697	0.853	0.486	0.199	-3.178	-0.909	0.226	-2.857	-1.079	-1.069	1.013	3.014	-1.661	-0.283	1.361	0.191	0.761
1964-65	10.415	2.134	2.252	0.549	-0.075	2.314	0.390	0.184	1.007	0.189	0.214	2.851	0.490	1.318	0.113	1.902	0.237	1.014
1965-66	-16.779	-2.576	0.213	0.568	-1.651	-1.382	0.136	-0.608	-2.063	-0.167	-1.176	-4.432	0.131	0.398	-0.301	-0.221	-0.590	-0.590
1966-67	-18.477	1.091	1.553	0.186	-0.616	0.192	-0.408	-0.714	-3.292	-1.660	-1.811	-3.249	-0.093	-0.181	-0.329	0.884	-0.028	-3.445
1967-68	4.250	2.243	2.661	1.686	0.184	7.860	1.025	0.610	3.164	-0.373	0.582	1.125	0.153	0.908	0.194	2.029	0.213	-0.522
1968-69	10.041	1.260	0.035	0.463	-0.446	9.294	-0.141	-0.032	0.459	0.123	0.190	-1.554	0.125	0.713	-0.212	2.046	-0.927	1.321
1969-70	9.576	1.471	3.150	0.108	-0.234	10.492	0.561	-0.378	2.966	0.066	0.273	-0.039	0.311	1.102	0.373	2.079	0.344	1.961
1970-71	15.392	-0.836	9.193	2.918	0.513	13.533	1.205	0.186	1.651	0.169	0.970	3.772	1.009	2,581	0.211	0.521	-0.132	1.354
1971-72	18.512	-0.756	3.890	-1.004	0.667	16.053	1.010	-0.202	1.287	0.316	0.131	2.807	0.359	-0.239	0.271	5.015	-0.043	0.467
1972-73	9.225	-2.285	4.498	0.763	0.104	11.492	0.483	-0.529	0.837	0.439	-1.986	-5.417	-0.072	1.881	0.205	1.890	0.046	2.434

* In the case of the 18 crops in Table 5a, the locational shift effect has been separated from the pure changes in their per hectare yields, whereas in the case of the remaining 14 crops in Table 5b, the variations in their All-India yields are taken as they are.

Table A-5b. Pure Yield Effect*

Absolute Changes in Productivity as Measured from the Base Period (triennium ending 1961-62=0) in Rupees

Year	Castor Seed	Coconut	Cotton Seed	Mesta	Tea	Coffee	Rubber	Black Pepper	Dry Chillies	Ginger	Turmeric	Potatoes	Bananas	Tobacco
1952-53	-0.071	0.488	-0.583	-0.179	-0.377	-0.376	0.088	-0.025	-0.343	-0.027	0.103	0.614	-0.123	-0.562
1953-54	-0.074	0.592	-0.173	-0.179	-1.622	-0.263	0.209	0.011	-0.393	0.021	0.088	0.472	-0.290	-0.161
1954-55	-0.010	0.456	-0.180	0.256	-0.801	-0.253	0.179	0.059	-0.073	0.006	0.144	-0.188	-0.311	-0.167
1955-56	-0.022	0.106	-0.634	0.231	-1.091	-0.094	0.256	0.064	-0.142	-0.013	0.282	-0.180	-0.289	-0.158
1956-57	-0.021	0.247	-0.023	0.211	-0.246	0.012	0.222	0.058	-0.217	0.008	0.227	-0.593	-0.217	-0.227
1957-58	-0.055	0.265	0.010	0.010	-0.531	0.081	0.092	0.021	-0.424	0.004	0.162	-0.562	-0.149	-0.604
1958-59	-0.055	0.226	-0.032	0.125	-0.243	0.038	0.035	0.017	-0.241	0.002	0.110	-0.097	-0.020	0.461
1959-60	0.011	0.196	-0.717	-0.053	-0.238	0.088	0.000	0.008	-0.165	-0.001	0.056	0.307	-0.054	-0.308
1960-61	0.000	0.043	0.750	-0.019	-0.393	0.007	0.000	-0.003	0.101	0.003	0.064	0.019	0.013	-0.021
1961-62	-0.011	-0.237	-0.060	0.049	0.632	-0.089	0.000	-0.005	0.053	-0.001	-0.100	-0.324	0.040	0.321
1962-63	-0.032	-0.142	0.622	0.075	0.349	-0.083	0.051	-0.040	0.337	0.003	-0.064	0.324	-0.029	0.581
1963-64	-0.034	-0.512	0.513	0.161	0.287	-0.040	0.087	-0.076	0.233	0.001	-0.046	-0.845	-0.010	0.417
1964-65	0.012	-0.486	0.637	0.057	0.951	-0.022	0.176	-0.077	0.318	0.000	-0.010	0.478	0.010	0.805
1965-66	-0.072	-0.740	-0.052	-0.117	0.639	0.312	0.250	-0.092	-0.464	0.007	-0.072	0.543	0.490	0.165
1966-67	0.079	-0.621	0.466	-0.092	0.841	0.643	0.965	-0.096	-0.415	0.001	-0.062	-0.110	0.693	0.521
1967-68	0.081	-0.677	0.768	-0.046	1.010	0.187	0.928	-0.114	0.076	0.006	-0.030	0.505	0.464	0.763
1968-69	0.118	-0.824	0.716	-0.242	1.411	0.483	0.940	-0.111	-0.222	-0.001	-0.117	0.857	0.170	0.443
1969-70	0.141	-0.765	0.739	-0.168	1.111	0.287	0.983	-0.123	-0.420	0.013	-0.054	0.441	0.069	0.115
1970-71	0.148	-0.627	0.145	-0.089	1.805	1.139	1.023	-0.108	0.324	0.063	-0.077	1.443	-0.158	0.375
1971-72	0.207	-0.789	1.847	-0.067	2.106	0.315	1.067	-0.105	0.253	0.068	-0.090	1.342	-0.193	1.049
1972-73	0.202	-1.017	0.976	-0.026	2.560	0.630	1.074	-0.105	-0.214	0.073	-0.111	0.520	0.243	0.560

* In the case of the 18 crops in Table 5a, the locational shift effect has been separated from the pure changes in their per hectare yields, whereas in the case of remaining 14 crops in Table 5b, the variations in the All-India yields are taken as they are.

Table A-6. Percentage Share of Crops in Total Cropped Area: Actual

Year	Rice	Wheat	Jowar	Bajra	Groundnut	Sugarcane
1952-53	22.85	7.49	13.37	8.21	3.66	1.32
1953-54	22.56	7.77	12.80	8.79	3.06	1.02
1954-55	21.91	8.02	12.44	8.09	3.95	1.15
1955-56	21.84	8.57	12.03	7.86	3.56	1.28
1956-57	22.18	9.29	11.16	7.73	3.80	1.41
1957-58	22.24	8.08	11.92	7.69	4.42	1.43
1958-59	22.16	8.43	12.00	7.64	4.18	1.30
1959-60	22.48	8.89	11.77	7.11	4.28	1.42
1960-61	22.61	8.56	12.20	7.60	4.28	1.60
1961-62	22.41	8.77	11.79	7.29	4.45	1.59
1962-63	22.98	8.75	11.85	7.06	4.69	1.44
1963-64	23.02	8.67	11.81	7.14	4.43	1.45
1964-65	23.18	8.53	11.48	7.52	4.69	1.65
1965-66	23.09	8.18	11.51	7.79	5.01	1.85
1966-67	23.05	8.39	11.80	8.00	4.77	1.50
1967-68	22.81	9.39	11.53	8.02	4.73	1.28
1968-69	23.53	10.16	11.92	7.67	4.51	1.61
1969-70	23.34	10.30	11.53	7.74	4.41	1.70
1970-71	23.13	11.22	10.69	7.94	4.51	1.61
1971-72	23.35	11.84	10.38	7.28	4.64	1.48
1972-73	23.26	12.89	9.57	7.57	4.44	1.60

Table A-7. Percentage Share of Crops in Total Cropped Area: Hypothetical

Year	Rice	Wheat	Jowar	Bajra	Groundnut	Sugarcane
1952-53	21.84	7.56	12.45	8.25	3.50	1.14
1953-54	21.75	7.48	12.56	8.40	3.53	1.13
1954-55	21.60	7.55	12.58	8.51	3.51	1.13
1955-56	21.57	7.59	12.48	8.61	3.46	1.12
1956-57	21.47	7.59	12.45	8.75	3.43	1.09
1957-58	21.71	7.68	12.39	8.64	3.43	1.14
1958-59	21.82	7.67	12.25	8.66	3.36	1.13
1959-60	21.73	7.72	12.21	8.71	3.33	1.15
1960-61	22.22	7.68	12.10	8.56	3.31	1.15
1961-62	22.09	7.63	12.17	8.69	3.31	1.13
1962-63	22.24	7.71	12.07	8.57	3.30	1.16
1963-64	22.38	7.74	12.07	8.43	3.30	1.17
1964-65	22.39	7.80	11.96	8.53	3.24	1.18
1965-66	22.47	7.89	11.90	8.39	3.23	1.24
1966-67	22.32	8.03	11.90	8.45	3.23	1.27
1967-68	22.62	7.95	11.71	8.54	3.12	1.22
1968-69	23.02	8.27	11.69	7.87	3.16	1.34
1969-70	23.29	8.34	11.53	7.81	3.11	1.36
1970-71	22.79	8.45	11.50	8.16	3.07	1.39
1971-72	22.99	8.48	11.36	8.12	3.03	1.39

Table A-8. Price Relatives (Deflated) and the Deflator

Year	Rice	Wheat	Jowar	Bajra	Groundnut	Gur (Jaggery)	Rape & Mustard	Jute/Rice ratio	Index of Agri. Commodity Prices
1951-52	98.2	101.8	85.2	73.6	79.9	115.5	89.1	124.2	101.2
1952-53	110.1	127.1	102.9	87.3	74.7	99.3	67.4	59.0	86.5
1953-54	107.4	115.6	100.8	88.4	92.8	136.9	90.0	58.1	88.3
1954-55	108.6	114.6	94.9	81.8	73.8	145.8	100.1	80.2	72.1
1955-56	110.2	117.6	88.4	93.8	75.7	109.6	87.1	88.4	67.5
1956-57	103.4	108.9	122.4	103.5	80.4	96.2	106.2	76.6	89.0
1957-58	109.8	105.9	111.4	104.3	76.7	101.4	102.1	74.7	90.9
1958-59	105.5	121.5	97.8	99.6	79.3	118.2	91.9	65.5	95.2
1959-60	105.8	111.7	111.2	100.3	90.2	145.8	89.3	69.9	94.7
1960-61	99.8	95.8	104.9	95.3	91.1	113.3	92.3	114.7	103.2
1961-62	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1962-63	108.4	101.3	118.9	96.5	96.9	141.1	108.5	68.9	97.1
1963-64	115.1	102.7	100.5	93.8	93.5	190.0	100.1	62.1	102.9
1964-65	92.7	100.4	120.4	95.6	88.9	135.3	109.2	71.5	137.3
1965-66	89.8	97.9	109.8	101.9	93.1	95.3	105.4	96.3	152.3
1966-67	98.8	104.1	100.1	94.4	109.9	113.3	109.0	92.8	170.7
1967-68	106.7	113.7	105.0	99.0	87.8	222.0	109.5	55.5	188.0
1968-69	108.6	112.8	102.3	98.0	82.5	218.6	97.2	84.7	181.0
1969-70	101.4	110.9	99.3	98.2	102.9	99.4	101.7	73.3	193.7
1970-71	107.9	111.8	102.0	84.8	115.12	104.3	115.0	72.2	186.5
1971-72	109.3	111.3	112.6	81.4	105.6	156.4	114.4	67.8	186.9

Source: For price data, Office of the Economic Advisor to the Government of India.

Table A-9. Percentage Share of States in Area under Individual Crops

Year	Rice		Sugar cane		Wheat		Gram	
	Assam, Orissa, & West Bengal	Andhra Pradesh, Tamil Nadu & Karnataka	Karnataka, Tamil Nadu, & Maharash-tra	Uttar Pradesh, Bihar, Punjab, Haryana	Punjab, Haryana, Uttar Pradesh	Rajasthan, Maharash-tra, Gujarat, Madhya Pradesh	Punjab, Haryana, Uttar Pradesh	Rajasthan, Maharash-tra, Madhya Pradesh
1952-53	33.23	15.81	12.37	80.42	49.11	38.85	51.14	32.89
1953-54	32.37	18.04	14.66	76.94	49.16	39.64	53.36	32.49
1954-55	31.60	18.69	15.26	75.73	47.94	41.36	54.14	32.58
1955-56	31.46	18.63	13.89	77.43	47.37	45.11	53.21	34.11
1956-57	30.85	19.38	13.44	77.97	43.54	46.14	50.20	36.73
1957-58	30.99	18.97	14.49	76.76	47.62	42.64	50.52	32.36
1958-59	29.95	19.16	15.43	75.63	46.39	42.94	49.07	34.44
1959-60	30.91	19.16	15.55	75.11	43.82	46.08	51.33	37.35
1960-61	29.88	19.29	16.26	73.50	46.05	43.15	53.51	35.20
1961-62	29.78	19.71	16.15	74.39	45.49	43.90	50.39	37.27
1962-63	30.02	20.47	15.64	74.61	45.87	44.10	51.48	36.33
1963-64	29.67	19.77	18.46	70.74	43.47	43.94	51.09	37.41
1964-65	29.65	19.90	18.87	69.91	46.52	43.43	52.78	36.03
1965-66	30.38	19.14	17.53	71.00	50.43	38.70	50.80	37.75
1966-67	30.54	20.07	18.87	71.52	52.49	35.70	51.07	38.91
1967-68	30.23	19.77	23.64	66.51	50.75	36.86	48.26	41.01
1968-69	30.32	18.45	24.35	65.94	51.44	36.04	47.31	41.63
1969-70	30.90	18.84	22.06	67.70	51.41	35.38	48.64	41.22
1970-71	30.41	19.61	21.74	68.93	51.12	35.62	44.42	45.99
1971-72	30.73	18.15	21.93	68.33	50.30	35.33	43.51	47.54
1972-73	32.19	17.29	20.92	69.17	50.22	30.74	45.13	45.21

Table A-10. Fertilizer Use, Index of Fertilizer Prices and Area Under High-Yielding Varieties of Seeds

Year	Fertilizer use/ net cropped hectare (Kgs.)[a]	Index of fertilizer prices deflated[b]	Total area under HYV of seeds as ratio of gross cropped area
1961-62	2.83	1.000	0.000
1962-63	3.51	0.969	0.000
1963-64	4.16	0.889	0.000
1964-65	4.79	0.718	0.000
1965-66	5.52	0.685	0.000
1966-67	8.76	0.619	0.012
1967-68	8.34	0.659	0.037
1968-69	12.17	0.701	0.058
1969-70	14.34	0.672	0.069
1970-71	15.51	0.675	0.093
1971-72	18.81	0.679	0.109

[a]Including nitrogen, phosphorous and potassium.

[b]Deflated by the official index of agricultural commodity prices.

Sources: For index of fertilizer prices and index of agricultural commodity prices, see Office of the Economic Advisor to the Government of India. For statistics of cropped area, see Government of India, Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics. For area under HYV, see Government of India, Ministry of Agriculture and Irrigation, Directorate of Extension. For data on fertilizer use, see Fertilizer Statistics, 1973-74 (New Delhi: The Fertilizer Association of India, December 1974).