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A NEW EVALUATION

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THE INTENSIVE AGRICULTURAL DISTRICTS PROGRAM IN INDIA:

A NEW EVALUATION*

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As policy makers in the international development agencies have focused more attention to the agricultural sector, the need for improved program design has become more acute. This is particularly the case for programs and projects with the multiple objectives of growth, improved income distribution and increased employment. Economic theory has unfortunately had very little to offer to the designers of these programs. Neither the simplistic models of economic growth nor the dual economy models have offered any real insight into the technology discovery and diffusion process. Consequently it is especially important that an evaluation of past programs directed towards these objectives be made. In this paper we offer an evaluation of an important program which was designed to produce rapid productivity growth in India.

The Intensive Agricultural Districts Programme (IADP) was based on two main premises: First, it supposed that significant "economic slack" existed. That is, it supposed that economically relevant technology was available, but that farmers had not adopted it for reasons of ignorance or for lack of complementary inputs. Second, it was supposed that an intensive effort which "packaged" several programs would have a higher payoff than more diffused program activities. That is, scale economies

to the program effort were presumed.

Prior evaluations by D. Brown [Brown, 1972] and by the Government of India [G.O.I., 1963, 1966, 1967] while favorably disposed toward the program, nonetheless provided evidence which indicated that the program actually produced little or no increased agricultural output. These evaluations unfortunately were flawed, not only by a lack of objectivity but by an inappropriate interpretation of the evidence. Our evaluation, while based in part on more recent data, is also based on a more appropriate methodology. In contrast to the previous evaluations, we conclude that the program induced a very significant increase in the use of "modern" factors of production and hence of agricultural production. It did not, however, result in a major gain in "real" total factor productivity. The real economic growth produced was quite modest. However, the social returns to investment in the program were probably similar to those realized in other development projects.

I. Background and Objective of IADP

The Intensive Agriculture District Programme grew out of the Indian Government's concern for stagnating food production in the late 1950s and its desire to launch a 'new strategy' for agricultural development. An examination of the stated objectives of the Second and Third Five Year Plans shows how agriculture had been particularly neglected in the late fifties and then again somewhat rehabilitated at the end of that decade (although buffer stocks and credit subsidies account for a major part of the increase). Table 1 summarizes public sector development expenditure by plan period in India. A detailed breakdown of spending

on agricultural programmes is provided. The First Plan was essentially a compilation of projects in hand but agriculture was stated to have the highest priority [Government of India, 1951, p. 44]. Whether this was actually the case is another matter but what is significant is that the principal objectives of the Second Plan did not even include a mention of agriculture [G.O.I., 1956, p. 24]. Table 1 clearly shows the larger accent on industrialization in the Second Plan Period.

The increase in both production of foodgrains and in their yields per hectare had been quite steady until the mid-fifties but was stagnating by 1957-58. The Third Five Year Plan Document appeared to note this fact when it stated once again that the first priority belonged to agriculture [G.O.I., 1961, p. 49]. Although the outlays for agriculture do not bear out this concern there was some shift in priorities from the Second Plan. The Government of India had already invited an Agricultural Production Team (sponsored by the Ford Foundation) in 1958-59 to study the country's food problem and to make recommendations for coordinated efforts to increase production on an emergency basis. The team issued a report entitled India's Food Crisis and Steps to Meet It [G.O.I., 1959a] which the government accepted and asked a second team of agricultural experts to recommend specific measures. The first team had already provided a rationale for an IADP type programme but the second team expanded this into a specific 10-point programme¹ [G.O.I., 1959b]. Underlying the recommended programme were the following objectives:

1. To demonstrate in pilot districts the most effective ways of expanding food production by cooperative effort between the center, the state, the district, the block, the village and the individual cultivators.

TABLE 1

Expenditure During Plan Periods: Major Development Programs in India

	First 5-yr. Plan 1951-56	Second 5-yr. Plan 1956-61	Third 5-yr. Plan 1961-66	1966-69	Fourth 5-yr. Plan 1969-74
<u>Total Plan Expenditure</u>					
Annual Rs. Crores ¹ (current)	392	920	1715	2252	3182
Annual Rs. Crores (1961)	522	920	1260	1373	1760
<u>Share of Plan Expenditure (Percent)</u>					
1. Industry & Minerals	5	24	23	25	23
2. Transport & Communica- tions	26	28	25	18	20
3. Power	8	10	14	18	16
4. Soc. Services & Misc.	24	18	18	15	17
5. Major Irrigation & Flood Control	22	9	8	6	7
6. Community Development and Cooperation	4	5	4	3	2
7. Agricultural Programs	11	6	8	15	15
<u>Percentage Shares of Agricultural Program Expenditures (category #7)</u>					
A. Agr. Research	1.5	1.8	1.1	1.0	.7
B. Agr. Production Pro- grams (incl. IADP)	40.0	33.3	26.8	24.1	25.2
C. Minor Irrigation	44.0	34.3	37.3	31.3	21.4
D. Area Development & Soil Conservation	--	6.4	10.9	10.1	8.1
E. Forestry & Fisheries	6.9	10.3	9.5	8.1	7.2
F. Animal Husb. & Dairy	7.5	12.1	10.6	6.0	9.7
G. Mktng Credit & Buffer Stocks	--	1.8	3.8	20.4	27.7

Source: Indian Agriculture in Brief, 1971.

¹One Crore = 10 million.

2. To increase the income of the cultivator and his family.
3. To increase the economic resources and the potential of the villages.
4. To provide an adequate agricultural base for more rapid economic development and social betterment.

This approach was a departure from the earlier community development approach to rural areas in the fifties. Where the community development approach had regarded agricultural production as merely one sector of rural life, which had to be dealt with only in the context of other rural institutions, customs and activities, this program was attacking the production problem in an essentially technocratic manner. A further point to be noted is that the C.D. program was a country-wide one while IADP was very selective, focussing on one district in each state. According to the Third Plan the IADP was to contribute both to rapid increase in agricultural production in the selected areas and to serve as a 'pace-setting, path finding' experimental program developing new ideas in agricultural development [G.O.J., 1961, p. 316]. It is important to note here that the perception of the looming food shortage led the government to focus almost exclusively on increasing food output.

Seven districts were selected in 1960-62, a further eight in 1962-64 and the sixteenth in 1967-68 [see Appendix 1 for a listing]. The districts were selected under the following criteria:

1. The district should have assured water supply.
2. It should have a minimum of natural hazards.
3. It should have well developed village institutions like cooperatives and panchayats.

4. It should have maximum potentialities for increasing agricultural production within a comparatively short time.

This selection of districts was clearly not random. The supposition implicit in most discussions of the program is that the districts selected were "most likely to succeed." In fact, our evaluation shows them to have been "least likely to succeed" in the context of what this program could be expected to achieve.

The program was, in general, a massive effort. It was also relatively expensive. The actual expenditures by the Ford Foundation and the Government of India have not explicitly been made public. We can however come up with a reasonable estimate. D. Brown reports a figure of 30 million dollars for the first five years of the program [Brown, 1971, p. 14]. This is consistent with the state budget data for this period, which indicate a 1-1/2 to 2 million rupee annual expenditure in each of the 15 districts. (These data do not include administrative and training expenditures.) The state budget data reflect an increase in the spending in the second five years of roughly 50 percent. To date, then, this program has been approximately a 100 million dollar experiment. It cost roughly one half as much as the research activities in India devoted to improved crop production for the entire country during the 1960's. [Mohan, Jha and Evenson, 1973, Table 1.]

II. Prior Assessments

One of the ten points in the IADP was the provision of continuing assessment and evaluation of the program. There exists therefore a large number of studies concerning the program at all levels: district, state

and national and by the Ford Foundation . At the district level, in addition to the annual progress reports, most of these studies concern particular localized problems and crops. The Ford Foundation had a continuing stream of studies reviewing and evaluating the program until it formally disengaged from it in 1971. There have been four main Government of India assessments [G.O.I., 1963, 67, 70a] and one independent assessment by Dorris D. Brown [Brown, 1971].

The Government of India's assessments review the performance of each district in administrative and physical terms e.g. number of farm plans adopted, amount of credit disbursed, number of credit societies, fertilizer used and area, production and yield of principle crops. They also recommend administrative and other reforms to improve implementation of the program at each stage. They do not, however, provide economic evaluations in a cost-benefit or comparative sense.

Dorris Brown's study covered the period of the first five years of the program. He utilized two measures of change in his evaluation:

1. Compound rates of growth of production, area and yield levels of all crops from 1956-57 to 1965-66 in each district in the country.
2. 'Indices of change' comprising the quotient of the average value of these variables during the IADP period (1961-66) divided by that in the previous five years.

He used these measures as a basis of comparison between the IADP districts and others in the same state, asserting that:

"If IADP has had a major impact on food grain crop output and productivity, then ten-year growth rates and the indices of change calculated for IADP districts should be significantly higher than zero and significantly different and above the same items calculated for bordering districts and other districts in the same states." [Brown, 1971, p. 29]

Part of the rationale for this hypothesis is that comparison of the IADP districts with bordering districts automatically controls for effects of weather and other uncontrolled variables--assumed to be similar in these districts.

His results showed that only 3 of the 15 IADP districts reported significantly higher rates of change in output and yield for food grains during the IADP period when compared with the previous five years. Only 2 IADP districts reported significantly higher changes in outputs of food grains than did bordering districts, but cultivators in IADP districts did somewhat better with increased output of cash crops. These data led Brown to conclude that the IADP program did not have an impact on growth in output or on growth in yields per hectare. Nonetheless he offered a strong defense of the program in terms of improvements in input markets and of increased use of modern inputs. He also claimed a somewhat more rapid adoption by IADP farmers of the new "green revolution" technology but had little data to offer.

Surely these data should give the contemporary advocates of rural development projects pause. Most observers would agree that in most of the districts a serious effort to improve production was made. The IADP districts had, for example, about twice the number of extension personnel as in other districts. They were probably more skilled as well. A high

degree of cooperation and support by farm leaders was achieved. Input and credit suppliers, whether public or private, generally worked to achieve success in the program. If such a program failed to produce real productivity gains in the Indian setting, it is difficult to imagine that programs modeled after it could be successful in other countries.

But these prior evaluations, including the third GOI report, were faulty on several grounds. The measures of productivity gain utilized were not appropriate, and the implicit "model" utilized to "test" the IADP effect was not properly developed. Before developing our specification for evaluating productivity gains we present a partial updating of previous measures used. Table 2 reports yield levels and their growth rates for 6 IADP districts. These are compared with the figures for the states they are located in. Brown's evaluation covered the period from 1956-57 to 1965-66. We report growth rates for that period and also for 1961 to 1971 which is the period of operation of the program. The variations due to weather effects are of sufficient significance to call for basing the growth rate calculations on 10 year periods.² The yield levels reported in columns 5-9 are two year averages. The main points to note from this table are:

i) Only one district of the six did significantly worse than its state during the IADP period in terms of growth in yields.

ii) Only three can be said to have done significantly better.

iii) Rather different results are obtained for the two periods considered.

iv) There is considerable variation between regions.

To obtain an understanding of these changes and the underlying forces at work we require a more systematic approach.

III. Toward an Improved Specification

The most widely used indicator of agricultural productivity for comparisons over time and across regions has been crop output per unit land. It is, of course, an incomplete or partial measure, although it has served a useful purpose in many analyses. It is far superior to other partial productivity measures, such as output per unit labor. The more meaningful measure in this context is the Total Factor Productivity (TFP) index, which is specifically designed to measure output changes net of the contribution of all conventionally measured inputs. That is, it is a measure of the contribution to production of activities such as technology discovery and diffusion activities and efficiency inducing activities, not normally measured in terms of inputs.

Simple yield measures then are subject to limitations because they fail to take into account changes in the utilization of inputs other than land (fertilizer, water, mechanical inputs). Even if these biases were not too serious, the failure to control for the contribution of technology discovery and diffusion activity (other than IADP activities) is.

We develop the TFP index as follows:

Consider the production function

$$Y = F(X_1 Q_1 T_1, X_2 Q_2 T_2, \dots, X_n Q_n T_n) \quad \dots(1)$$

TABLE 2

Yield Levels and Growth in Selected IADP Districts

	Comparison of Yield Levels				Compound Growth Rates (of Yield)			
	District		State		1956-66 ^(a)		1961-71 ^(b)	
	59-61	69-71	59-61	69-71	District	State	District	State
	<u>Q/ha.</u>	<u>Q/ha.</u>	<u>Q/ha.</u>	<u>Q/ha.</u>				
1. Thanjavur (Tamilnadu) Rice	15.0	16.0	14.3	18.3	2.11	0.65	0.11	1.97
2. W. Godavari (Andhra Pradesh) Rice	12.8	16.2	12.5	14.0	2.45	1.43	2.12	1.09
3. Raipur (Madhya Pradesh) Rice	8.7	11.2	8.1	7.9	-3.31	-3.16	3.80	0.89
4. Sambalpur (Orissa) Rice	9.4	9.6	9.3	9.6	5.25	6.87	1.07	0.96
	<u>Rs/ha.</u>	<u>Rs/ha.</u>	<u>Rs/ha.</u>	<u>Rs/ha.</u>				
5. Aligarh (Uhar Pradesh) All foodgrains	276	570	288	397	4.29	1.58	6.93	4.66
6. Ludhiana (Punjab) All crops	474	1023	384	690	6.11	2.01	7.93	7.48

Notes: (a) D. Brown's evaluation period. (b) IADP period.

where F is homogeneous of degree 1, Y is a measure of output
 X_1, X_2, \dots, X_n are conventionally measured inputs: land, labor,
 fertilizer, etc.

Q_1, Q_2, \dots, Q_n are indexes of measurable quality

T_1, T_2, \dots, T_n are indexes of factor augmenting technical change.

The implication is that while (Q_i) can, in principle, be measured
 (T_i) cannot. (This distinction is somewhat arbitrary, but useful in
 view of the considerable literature on the "explanation" of measurement
 usually often fails to capture changes in the productive productivity
 change.) Under the assumption that F is homogeneous of degree 1 and that
 producers maximize profits, we differentiate (1) with respect to time to
 obtain:

$$\frac{\dot{Y}}{Y} = \frac{dY/dt}{Y} = \sum_{i=1}^n S_i \left(\frac{\dot{X}_i}{X_i} + \frac{\dot{Q}_i}{Q_i} + \frac{\dot{T}_i}{T_i} \right) \quad \dots(2)$$

where the S_i are input shares in total cost.

Percentage change in output is therefore a weighted average of
 percentage changes in measured inputs, measured input qualities, and
 factor-augmenting technical change. The TFP index, \dot{P}/P , is defined as:

$$\frac{\dot{P}}{P} = \frac{\dot{Y}}{Y} - \sum_{i=1}^n S_i \frac{\dot{X}_i}{X_i} = \sum_{i=1}^n S_i \left(\frac{\dot{Q}_i}{Q_i} + \frac{\dot{T}_i}{T_i} \right) \quad \dots(3)$$

M.K. Richter [Richter, 1972] has shown that this "Divisia" index of productivity
 change is the appropriate general measure. The appropriate productivity index
 is a chain linked index of weighted growth rates of inputs (and outputs)
 with the weights changed often.

This formulation can be modified slightly to incorporate departures from profit maximization by adding a term for economic "errors,"

$$\frac{\dot{P}}{P} = \sum_{i=1}^n s_i \left(\frac{\dot{Q}_i}{Q_i} + \frac{\dot{T}_i}{T_i} \right) + \alpha_i \left| \frac{\dot{F}_i}{F_i} - \frac{\dot{W}_i}{W_i} \right| \quad \dots(4)$$

(F_i is the marginal product of input i , W_i is the input's price)

We can now see the basis for utilizing this relationship to identify the contribution of a program such as IADP. The distinction between Q_i and T_i in (4) is based on measurability and is the issue in the growth "explanation" literature [Griliches and Jorgenson, 1966, and Denison, 1962]. For our purposes we will simply note that factor quality improvement, factor augmenting technical change and economic error reduction are the consequence of the systematic effort of researchers, extension agents and factor suppliers to discover and diffuse technology. An important point must be made here with respect to the economic error term. The "partial" effect of the introduction of improved technology will result in an increase in the economic errors, holding constant extension activity and producer learning activity. The partial effect of an increase in extension effort, and of improved marketing of inputs will be to reduce these errors, but at a diminishing rate. The IADP program was based on the supposition that economic errors, both by producers (as reflected in the error term in (4)) and by input suppliers were large. These errors form a kind of "economic slack" that essentially provided the scope for the effectiveness of programs such as IADP which do not directly pursue technology discovery.

The rate of measured total factor productivity growth in a district then would be determined by:

1. The application by producers of new economically relevant technology which originates from three sources:
 - a. Discovery activity directed toward producing technology suited to use under the soil, climate and economic conditions of the district.
 - b. Discovery activity directed toward technology development suited to economic, soil and climate conditions significantly different from those of the district, but which is, nonetheless, superior to existing technology.
 - c. Discovery activity by producers themselves who modify and "adapt" new technology to farm-specific conditions.
2. The reduction of economic "slack" or economic and technique choice errors. These improvements can result from:
 - a. Improvements in technique choice by farmers, that is, the adoption of existing technology which is superior to that in use.
 - b. Improvements in allocative efficiency by farmers that is utilizing resources in a more cost-minimizing fashion. (Broadly interpreted, allocative efficiency would encompass technique choice.)
 - c. Improvements in factor supply efficiency, including credit.

Now we turn to the development of an econometric specification with which to identify the effect of IADP programs. Basically the test of the contribution of IADP programs, which are chiefly designed to reduce economic slack, has to be made in terms of associating increased

total factor productivity with IADP activities, holding constant the contributions of technology discovery activity and geo-climate factors, and controlling for the initial level of economic slack. The prior evaluations of Brown and GOI did not attempt to take into account the fact that the level of economic slack existing at the beginning of the program in 1961 was in all probability lower in the IADP districts than in the non-IADP districts. This was the result of the selection process used. As a consequence of this selection, the IADP districts had the least scope for realizing the gains that IADP programs were designed to achieve. Without an IADP program these districts would have been expected to do less well in terms of productivity growth than non-IADP districts in the 1960's.

Our econometric specification is of the following form:

$$\begin{aligned} TFP_{it} = & C + b_1 DIADP_i + b_2 DREG_i \\ & + b_3 DDR_{it} + b_4 SR_{it} + b_5 RR_{it} \\ & + b_6 (SR \times RR)_{it} + b_7 TFP5661_i \\ & + \epsilon . \end{aligned} \quad \dots(1)$$

Here

TFP_{it} is a district total factor productivity index (1960-61=100)

$DIADP_i$ is a dummy variable for IADP districts (equalled 1 for IADP, 0 for non-IADP districts).

$DREG_i$ is a set of 13 dummy variables for agro-climate regions.

DDR_{it} is a dummy variable for drought years which assumes a value of 1 when output is 10% below trend.

SR_{it} is a measure of technology discovery activity directed toward the district. It is the cumulated expenditures on research in the state in which the district is located from 1948 to t deflated by the 1960 value of all inputs devoted to agricultural production in the state. A lag was introduced into the variable by the following cumulation process:

$$SR_{it} = \frac{1}{D} \left\{ \sum_{1948}^{t-5} R_t + .8R_{t-4} + .6R_{t-3} + .4R_{t-2} + .2R_{t-1} \right.$$

where R_t is the research expenditure in time t in the state and D is the deflator used.³

RR_{it} is a measure of research outside the state, but within the same geo-climate region. [Constructed in the same way as SR_{it} .]

$(SR \times RR)_{it}$ is an interaction term, the multiple of state based research and geo-climate regional research. We include this to take account of the interaction between SR_{it} and RR_{it} since one is to some extent a substitute for the other. This term also introduces non-linearity.⁴

$TFP5661_i$ is the rate of change in total factor productivity in the district from 1956 to 1961. It is a proxy measure of economic slack existing in 1961--the start of the program.

The parameters of this specification were estimated with data for 140 districts (i) for the years 1960-71 (t). The 140 districts are located in 7 states and include 7 IADP districts. Figure 1, shows the location of the 7 IADP districts, and the delineation of 14 agro-climate regions

into which the 140 districts are grouped. A further aggregation of the 14 agro-climate regions into 5 geo-climate regions is also shown in the notes to the figure.

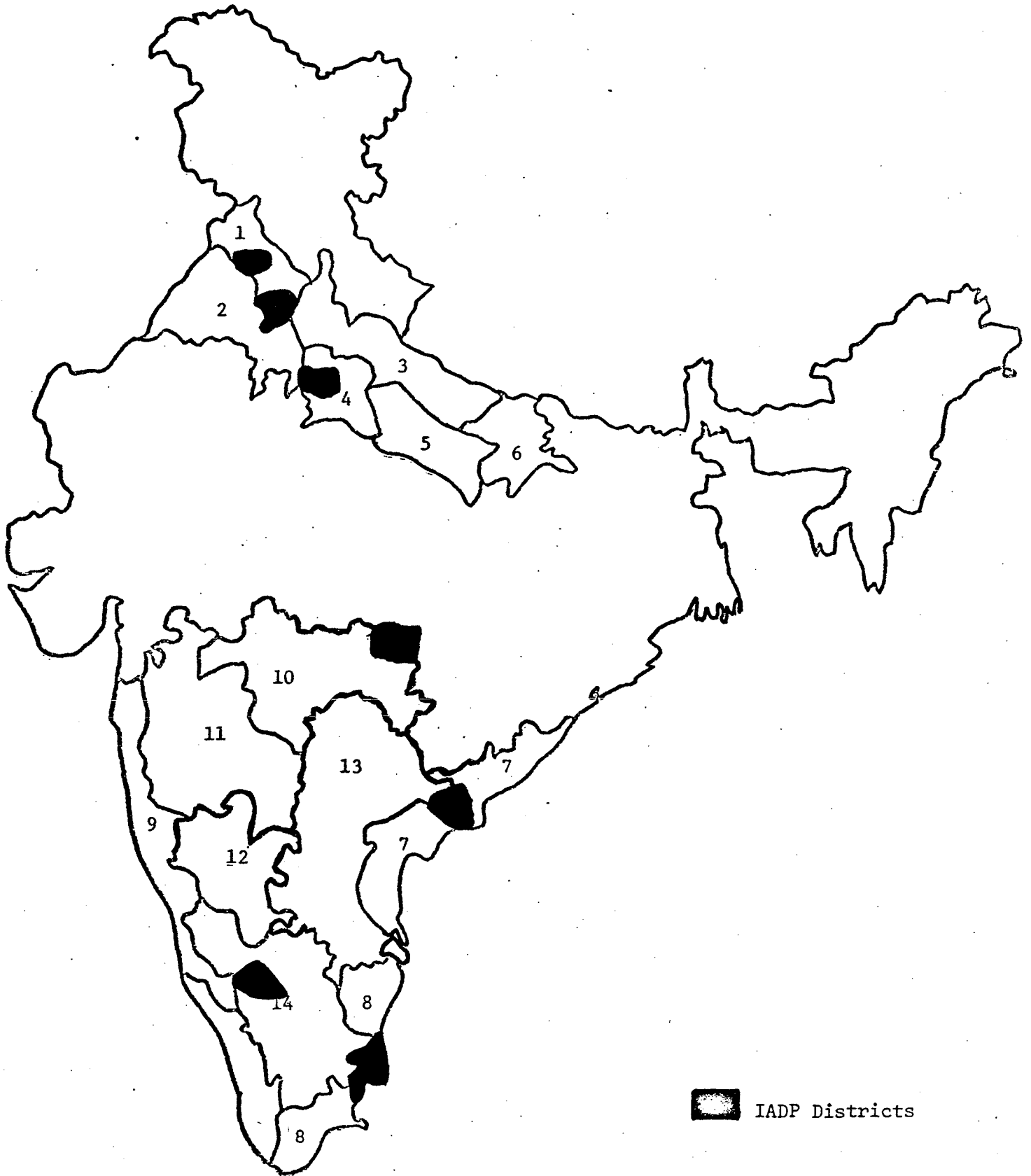
Modifications of this basic specification and a further definition of the variables are discussed in the following section. Before turning to the results of our investigation we discuss two issues: the measurement of total factor productivity and the use of regions.

The calculation of total factor productivity measures for Indian Districts necessarily involves some interpolation of data series and some degree of judgment in resolving inconsistencies between alternative data series. The input data covers land, fertilizer, pump irrigation, tractors, implements, bullock labor and human labor. We provide detailed notes on our calculations and sources in Appendix (2). The major details of the construction are:

1. The output series is a price weighted Laspeyres index (base-year: 1960) of agricultural commodities. Almost all the commodities reported in GOI publications have been included.
2. The input series is computed as an input share weighted index of the Divisia type of rates of input growth. (Table reports the mean shares over the period.)
3. Input growth rates were calculated on an annual basis for land, fertilizers, pumps and tractors (after 1960). For animal power and implements the growth rates were based on livestock census data for 5-year intervals. The labor input growth rate was calculated as a constant rate between 1951, 1961 and 1971 census.

Figure 1

Agro-Climate Regions of India and IADP Districts



Notes to Figure 1:

Subtropical Monsoon Geo-Climate Region

Agro-Climate Region 1	North Punjab Wheat Area (IADP Dist. Ludhiana)
" " " 2	Punjab-Haryana U.P. Dry Wheat Area (IADP Dist. Karnal)
" " " 3	Western U.P. Wheat Sugarcane Area

Hot Subtropical Geo-Climate Region

Agro-Climate Region 4	South Central U.P. Wheat-Bajra Area (IADP Dist. Aligarh)
" " " 5	East Central U.P. Rice-Pulses Area
" " " 6	South East U.P. Rice-Grain Area

Hot Equatorial Geo-Climate Region

Agro-Climate Region 7	A.P. Coastal Area (IADP Dist. West Godavari)
" " " 8	Tamil Nadu Coastal (IADP Dist. Thanjavur)

Humid Equatorial Geo-Climate Region

Agro-Climate Region 9	Maharashtra-Mysore Coastal
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Semi-Arid Equatorial Geo-Climate Region

Agro-Climate Region 10	East Central Mah. Black Soils Area (IADP Dist. Bhandara)
" " " 11	West Central Mah. Black Soils Area
" " " 12	Northern Mysore Black Soils Area
" " " 13	Interior AP Red Soils Area
" " " 14	Southern Mysore-T.N. Red Soils Area (IADP Dist. Mandya)

See Appendix 3 for district delineation of agro-climate regions.

4. Input shares were computed for 1961, 1966 and 1971 and applied to the corresponding periods.
5. Each input is priced at market prices (or the best estimates of market prices available) in computing these shares. Thus all labor is priced at hired labor wage rates. Different wage rates for males and females for each state were used and National Sample Survey data on the number of days worked per year were utilized to obtain the labor shares. The justification for using market prices is, of course, that they are reasonable approximations to marginal products.⁵

The regional classification has two purposes. The agro-climate regional definition is designed to identify small regions with reasonably homogeneous cropping patterns and soil and climate conditions. Table provides a comparison of rates of change in measured total factor productivity for each of the 14 agro-climate zones and for the IADP districts included in the study. The agro-climate regions are based on the work of Easter [1972]. We note that only one of the seven IADP districts in the study actually realized a higher rate of change in productivity /than the average for the region in which it was located. We also note that there is little relationship between the average shares of capital (tractors and implements) and fertilizer and average yield levels of food grains or total factor productivity gains.

The second regional classification, the geo-climate classification is based on the work of Papadakis [1967]. It is a broader climate classification designed to identify climate regions of sufficient similarity

Table . District Total Factor Productivity Measures: Indian Agriculture, 1959-60 to 1970-71

Agro-Climate Region	Number of Districts in Region	Annual Regional Δ TFP 1960-71	Annual Δ TFP for IADP 1960-71	Average Level of Food Grain Yields		Input Shares	
				Tonnes/ha	L	K	Fert.
<u>Northern Regions</u>							
1. North Punjab wheat area	9	2.03	1.65	.523	.39	.13	.041
2. Punjab-Haryana-U.P. dry wheat area	9	6.07	1.80	.356	.40	.09	.017
3. Western U.P. wheat-sugarcane area	12	5.00	--	.313	.38	.18	.026
4. South-Central U.P. wheat-Bajra area	13	2.23	-.5	-.343	.41	.17	.018
5. East Central U.P. rice-pulses area	16	4.95	--	.292	.47	.18	.018
6. S.E. U.P. rice-grain	5	-.6	--	.259	.35	.18	.007
<u>Central and Southern Regions</u>							
7. A.P. Coastal	7	-.01	2.80	.400	.41	.11	.047
8. Tamil Nada Coastal	7	.29	-.7	.512	.43	.18	.016
9. Maharashtra, Mysore Coastal	6	.20	--	.421	.45	.14	.013
10. East Central Mah. Black soils area cotton-Jowar	10	1.28	0.0	.314	.44	.13	.017
11. West Central Mah. Black soils area Jowar-pulses-Bajra	13	2.08	--	.291	.47	.13	.021
12. Northern Mysore Black soils area Jowar-cotton	6	1.53	--	.214	.35	.10	.020
13. Interior A.P. Jowar Red soils-oilseeds-rice	14	-.50	--	.254	.38	.13	.021
14. Southern Mysore-T.N. Red soils area	13	3.10	2.47	.357	.45	.14	.045

that technology transfer can be expected to take place within the region. The geo-climate regions in India are located in other countries as well and some degree of international technology transfer is involved in the determination of productivity in India.

IV. The District Evidence

Table 4 reports six sets of parameter estimates based on available data for the 140 districts. Two alternative dependent variables, the total factor productivity index and an index of foodgrain yields per hectare are utilized. The basic regressions are regressions (1) and (4). We note that the state and regional research variables are significant contributors to the statistical explanation of both productivity change and foodgrain yields. The state and regional research interaction variable is negative and significant thus confirming our expectations. The early period productivity index has a significantly negative coefficient as expected on the grounds that the higher the early period productivity gains, the lower is economic slack at the beginning of the period and therefore the lower the potential for TFP gains in future periods.⁶

The IADP effect in regression (1) and (4) is picked up by the IADP dummy coefficient. It is positive in both cases. The statistical quality of the estimated effect is low in the case of regression 1, however. In regression 4, the estimated contribution to increased foodgrain yields is highly significant both from a statistical and economic point of view. This is pretty much what should have been expected of the program. By inducing producers to increase the use of fertilizer

and modern inputs a large effect in yield levels should have been forthcoming. As we have noted, however, the real test of the contribution of the program is in terms of productivity change. Our estimate shows this contribution to have been positive.

Some supporters of IADP would argue that the real effect of IADP is that it made research more effective. Regressions 2, 3, 5 and 6 are designed to investigate whether the IADP had a strong interaction with the research program. The state and regional research variables are combined to form a new variable:

$$\text{DISTR}_{it} = \hat{b}_4 \text{SR}_{it} + \hat{b}_5 \text{RR}_{it} + \hat{b}_6 (\text{SR} \times \text{RR})_{it} \quad \dots(2)$$

where \hat{b}_4 , \hat{b}_5 and \hat{b}_6 are the estimated coefficients from regression 1. DISTR_{it} then measures the estimated contribution of all research to TFP in district i at time t . By multiplying this by the IADP dummy for IADP districts we get

$$\text{DDISTR}_{it} = (\text{DIADP}) \times \text{DISTR}_{it}$$

and for non-IADP districts

$$\text{NDISTR}_{it} = (1 - \text{DIADP}) \times \text{DISTR}_{it}$$

We then estimate the following equation:

$$\begin{aligned} \text{TFP}_{it} = & C + b_8 \text{DDISTR}_{it} + b_9 \text{NDISTR}_{it} \\ & + b_{10} \text{TFP5661}_i + b_{11} \text{DDR}_{it} + b_{12} \text{DREG}_i + e \quad \dots(3) \end{aligned}$$

The coefficients b_8 and b_9 test whether research affected the IADP districts and non-IADP districts in a different way. They allow us to test if the slope coefficient on the research variable differs in the IADP districts. Regression 2 indicates that the marginal contribution of research toward increased productivity is not higher in IADP districts. Regression 5 has yield as the dependent variable and it indicates that the marginal contribution of research toward increased yields is greater in the IADP districts. Regressions 3 and 6 add the IADP dummy variable allowing both the intercept and slope terms to differ for the IADP districts. We find that the slope coefficient in regression 3 is greater for non-IADP districts, i.e. the marginal contribution of research to non-IADP districts is greater than to IADP districts while the opposite is true for yields.

Figure 2

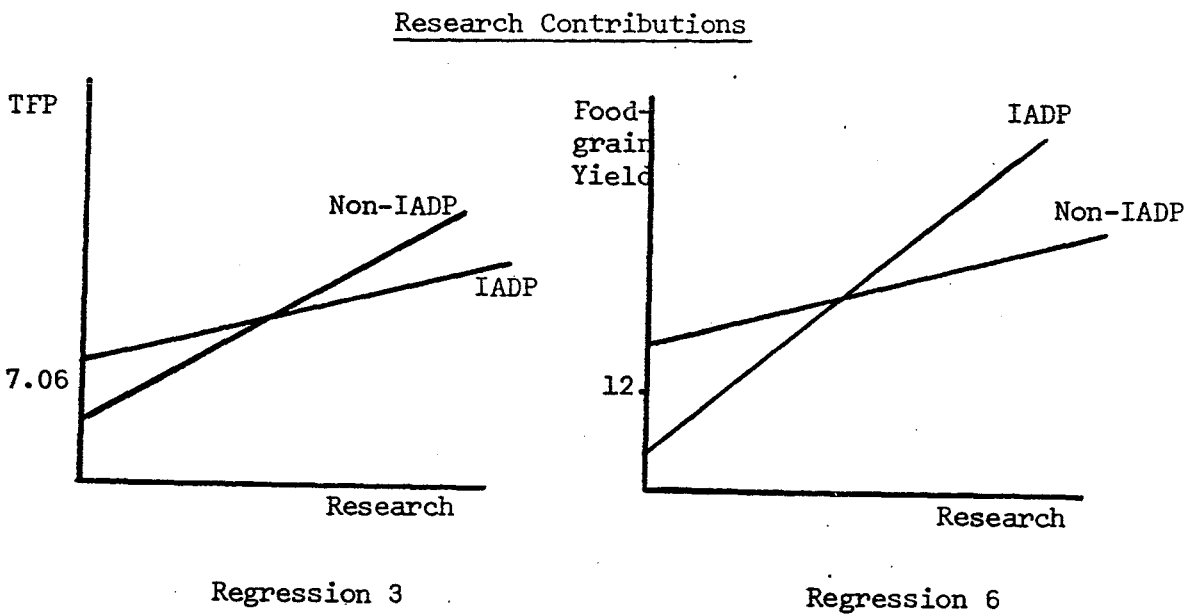


Table 4. District Regression Analysis

140 Districts: 14 Agro-Climate Regions: 1960-71

Regression #	Dependent Variable: Total Factor Productivity (1960=100)			Dependent Variable: Foodgrain Yield Index (1960=100)		
	(1)	(2)	(3)	(4)	(5)	(6)
<u>Independent Variable</u>						
State Research (SR)	.655 (3.54)			.97 (5.71)		
Regional Research (RR)	.373 (4.72)			1.15 (12.78)		
(SR) x (RR)	-.0042 (3.23)			-.024 (6.00)		
DDISTR _{it}		.987 (5.91)	.721 (2.95)		3.12 (21.20)	3.65 (16.59)
NDISTR _{it}		.992 (8.41)	1.017 (3.55)		2.15 (19.45)	2.14 (19.45)
Early Period TFP (TFP5661)	-7.45 (4.54)	-7.39 (4.51)	-7.56 (4.61)	-9.2 (6.13)	-8.6 (5.73)	-7.6 (4.62)
Dummy for IADP (DIADP)	2.00 (.78)		7.06 (1.49)	14.2 (5.92)		-12.0 (3.79)
R ²	.44	.44	.44	.51	.50	.53

Notes: "t" ratios in parentheses

All regressions include dummy variables for 14 Agro-climate Regions

DDISTR_{it} defined as DIADP multiplied by
[.655 SR + .373 RR -.00042 (SR)x(RR)] (from eq. 1)

NDISTR_{it} defined as (1 - DIADP) times
[.655 SR + .373 RR - .0042 (SR)x(RR)] (from eq. 1)

A dummy variable for drought years when output was more than 10 percent low trend is included as an independent variable. Dummy variables for Agro-climate regions are also included in the regressions.

These relationships indicate that IADP programs complemented the research inducement to increased yields, but substituted for research in terms of the contribution to total factor productivity. That is it increased the marginal contribution or "product" of research toward increasing yields, but decreased the marginal contribution of research to total factor productivity. This result is quite plausible since, many of the IADP activities would be expected to substitute for research.⁷

V. The Economic Implications

This evaluation is based on data not available when earlier appraisals of the IADP program were made. The evaluation model employed in this paper differs in major respects from those utilized earlier as well. It is not surprising, then, that we reach somewhat different conclusions. In contrast to the previous evaluations, we find that the IADP programs had a large and significant effect on foodgrain yield performance. It induced the adoption of significant increases in modern inputs, especially fertilizer, from an already high level to a still higher level. When these increased inputs are "netted out" in the total factor productivity computation, the contribution of the IADP program has been modest. That is, it did not produce the major increases in production expected of it. In contrast, in an earlier paper [Evenson, 1973] truly extraordinary gains were attributed to the Indian agricultural research system.

That its contribution to real economic growth was modest relative to the contribution of the Indian agricultural research system is, again, not surprising. The evidence provides support for our hypothesis that the IADP programs were undertaken in those districts in which the expected contribution of these programs was lowest. That is, districts with relatively low economic slack were chosen. Had the program been instituted in more "backward" districts, we believe that a much larger impact would have been realized.⁸

Our evaluation has been based on a model in which technology discovery by formal research programs is the key "engine" of growth. Programs such as IADP can reduce economic slack and effect some technology transfer within regions. They can induce experimentation with modern inputs which is of value in terms of producing skills. They can remove input market distortions (and they can create distortion through input subsidies). They do not discover new technology, however, and their contribution depends heavily on whether technology discovery and diffusion is taking place. We share the perspective of prior evaluations that IADP has not been a primary source of real growth.

Nonetheless, we certainly do not conclude that it has not had a major impact. It clearly induced modern input adoption. The fact it induced modern input adoption without inducing more total factor productivity growth suggests that implicit or explicit subsidies for fertilizer

and tractor purchases are not means of purchasing real economic growth from a social point of view. We should note, however, that our total factor productivity calculations attributed perhaps too much production growth to these modern inputs since the prices used to compute the share weights were market prices. If prices were actually lower to IADP farmers, a calculation based on these lower prices would have resulted in a higher growth in total factor productivity in the IADP districts since less output growth would have been attributed to the modern inputs. From a social point of view, however, the subsidies, to the extent that they were undertaken, represent inefficiencies. In all likelihood they also had a regressive effect on income distribution, though we have not addressed ourselves to distributional effects. Some "learning from experience" associated with the modern input use, would be of economic value, but we do not see evidence that Indian farmers are unable to learn about and adopt new inputs.

In terms of economic payoff to the IADP program, we have from Regression 1, Table 5, an estimated 2 percent higher level of output for the 1960-71 period in the IADP districts. The value of this output in the 15 IADP districts is approximately 75 million rupees per year (1968 prices). Presumably, it is increasing over time and will continue beyond 1971, but will not be permanent. The estimated costs of the IADP programs were from 30 to 40 million rupees per year in the early years rising to 50 million or so in later years. It appears from these data that the flow of social returns generated by the program has been sufficient to yield a reasonable rate of return. The actual rate will depend on the permanence of the benefits stream in the years after 1971

and the time lag between program spending and results. Our estimate is that with the benefits flow extending to 1975, the internal rate of return has been in the neighborhood of 15 percent. This estimate is based on the estimated productivity effect which is of low statistical quality.⁹

Thus the IADP program probably had a payoff of approximately the same order of magnitude as other development efforts with the glaring exception of investment in research. A detailed study of the contribution of the Indian agricultural research system to output is reported elsewhere [Evenson, 1973]. That study, which was based on state data, reached the conclusion that the major determinant of productivity change in Indian agriculture was the research activity within India. An estimated internal rate of return of 45 to 50 percent for research investment was derived. The comparable estimate for the conventional extension program was 17 percent.

Thus, it would appear that the IADP program yielded social returns of approximately the same order of magnitude as realized in the more conventional extension program.

FOOTNOTES

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¹The ten-point program was: (1) Provision of adequate credit to cultivators; (2) Assured supplies of all inputs--fertilizers, pesticides, improved seeds, implements at bullock-cart distance of each village; (3) Assured prices; (4) Improved market structure; (5) Intensive technical, water management and farm management assistance; (6) Direct and individual farm planning; (7) Village planning; (8) Public works program; (9) Analysis and evaluation of the program; (10) Extraordinary organizational and administrative changes necessary to carry out the program.

²Variations due to weather effects made calculations of growth rates impractical for shorter periods.

³The form of the lag structure is derived from [Evenson, 1971]. The expected negative sign on this term partially reflects diminishing returns to research. With a high degree of collinearity between SR and RR it functions as a squared term for SR.

⁴See [Evenson, 1973] for further discussion of technology borrowing within and across regions.

⁵This is a debatable assumption but most econometric studies have reached this conclusion [Rao, 1965; Saini, 1969; Evenson, 1972].

⁶An additional argument for inclusion of the early period productivity gains is that weather factors create a "regression" effect that is partially controlled for by this variable. If beginning period weather factors are exceptionally favorable, this will lower the rate of productivity growth measured in following periods. It will also be reflected in higher pre-IADP productivity growth.

⁷This result is similar to the implication of the negative interaction term between state and regional research.

⁸Not all "backward" districts have a high degree of economic slack, of course. The existence of slack depends on the discovery of region-specific relevant technology and on relatively low investment in slack reducing activities.

⁹This supposes a 2-year average lag between IADP expenditures and the realization of benefits.

Appendix (1)

<u>State</u>	<u>District</u>	<u>Year Started</u>
Andhra	West Godavari ⁺	1960-61
Assam	Cachar	1963-64
Bihar	Shahabad	1960-61
Gujarat	Surat and Bulsar	1962-63
Haryana	Karnal*	1967-68
Jammu and Kashmir	Jammu and Anantnag	1963-64
Kerala	Alleppey and Palghat	1962-63
Madhya Pradesh	Raipur ⁺	1961-62
Maharashtra	Bhandara ^{#1}	1963-64
Mysore	Mandya*	1962-63
Orissa	Sambalpur ⁺	1962-63
Punjab	Ludhiana ^{#+}	1961-62
Rajasthan	Pali ¹	1961-62
Tamil Nadu	Thanjavur ^{#+}	1960-61
U.P.	Aligarh [#]	1961-62
West Bengal	Burdwan	1962-63

* Included in current study.

⁺ Ford Foundation selected Districts as 'Innovative Districts.'

¹ Dropped from programme (1967-68)

APPENDIX 2. Notes on Calculations of Total Factor Productivity for 140 Districts

1. The output index is calculated from
 - a. Government of India, Directorate of Economics and Statistics, Ministry of Food and Agriculture, Estimates of Area and Production of Principal Crops in India (1970) (Detailed Tables) 1954-55 to 1964-65.
 - b. State Statistical Abstracts and Crop and Season Reports for later years.

2. The input quantity indexes used in this calculation were:
 - a. Land: An annual index of net harvested acreage from the same sources as the output data.
 - b. Fertilizer: Data from a World Bank Study . W.B. Dönde and D.B. Brown, Effective Demand for Fertilizer in India. N.P. and K. treated as separate inputs.
 - c. Pump Irrigation: Data from livestock census, 1951, 1956, 1961. For 1966, 1967, 1968, from Economic and Social Indicators of India, USAID, 1972.
 - d. Tractors: Data on number of agricultural tractors interpolated between Census of Livestock, 1951, 1956, 1961 and 1966. After 1966 for later years from estimate given by MMA Baig, Manager, Market Research, Escorts Limited (correspondence to Rakesh Mohan, 10th July, 1972).
 - e. Implements: Wooden plows, Iron plows, cane crushers, Ghanis and carts from Indian Livestock Census, 1951, 1956, 1961, 1966. Linear interpolation between census and extrapolation after 1966.
 - f. Bullock labor: Male cattle used for work and male buffalo used for work, from Indian Livestock Census 1951, 1956, 1961, 1966. Linear interpolation between census and extrapolation of 1961-1966 trend to 1971. An adjustment for days worked per year was made from Farm Management Survey Data.
 - g. Human labor: Data on number of male cultivators and male agricultural laborers from Fact Book on Manpower, 1970. Institute of Applied Manpower Research, New Delhi and Provisional Population Totals, Paper 1 of 197 supp., Census of India--1971. Data on females, from the same sources. 1971 female data were not taken from 1971 census counts because of inconsistent definitions between 1961-71. Female growth rates between 1961 and 1971 were assumed to be the same as the actual growth rates in the male labor force. The number of days worked per year by male and female cultivators and laborers, from Fact Book on Manpower (N.S.S. data) were used to correct numbers of laborers into numbers of days worked separate growth rate between censuses for males and females were computed.

APPENDIX 2
(continued)

3. Input share data were computed using the following prices:

- a. Land: Rental values of irrigated and unirrigated land were computed from Punjab Farm Accounts annually for 1956 to 1970. This series was adjusted by comparison with cash rental data from several Farm Management Studies (summarized in C. H. Rao, Agricultural Production Functions, Asia, Pub. Aug. 1965, for early years) and taken from reports for several districts in later years. Andhra Pradesh (1961-62), Mysore (1960). Other data from 1959-60. Rural credit Survey data were also used. On the basis of these sources, a determination was made to use the Punjab-Haryana rental rates for irrigated and unirrigated land for the Northern states, Punjab-Haryana and U.P. These were our best estimates of the comparative prices based on the farm management study data. Irrigated land (excluding tubewells) was on the farm management study data. Irrigated land was treated as a separate input and the difference in the rental rates for irrigated or unirrigated land was assumed to reflect the public sector as well as private sector investment in canal irrigation.
- b. Fertilizer: Prices for nitrogen, phosphate, and potash from Fertilizer Statistics, Fertilizer Association of India.
- c. Pumpsets: Farm management data from the Punjab used to compute depreciation maintenance plus operating costs per tubewell. Irrigated acreage in the land series did not include this irrigation.
- d. Tractors: Prices from Agricultural Prices in India and from Escorts Limited.
- e. Implements: Prices from Tara Shukla, Capital Formation in Indian Agriculture, Vora and Co., Bombay, 1965, up-dated through wholesale price index.
- f. Bullocks: Prices obtained from Punjab Farm Account data and from Farm Management Survey data. Depreciation maintenance and fodder included in the overall price, since much livestock feed is not captured in the output data.
- g. Labor: Wage rates from Agricultural Wage Rates in India, (1971 data provided by the Ministry of Agriculture) were averaged over districts, months, and tasks. Males and females were given separate wages, and cultivators were given the same average wage as the field laborers.

4. The annual input index growth rates were weighted by 1960-61 factor share from 1963 to 1961-62, by 1965 shares from 1962-63 to 1967-68 and by 1970 shares for the remaining years. These weighted aggregate input index changes were incremented to form the input index.

Appendix 3Details of Regions:

<u>Region</u>	<u>Districts</u>
1. North. Punjab Wheat Area. 8 Districts	<u>Haryana:</u> Ambala, <u>Punjab:</u> Amritsar, Gurdaspur, Hoshiarpur, Jullundur, Kapurthala, <u>Ludhiana</u> , Patiala
2. Punjab-Haryana-U.P. Dry Wheat Area 10 Districts	<u>Haryana:</u> Gurgaon, Hissar, Mohindergarh, Rohtak, <u>Karnal</u> <u>Punjab:</u> Bhatinda, Ferozepur, Sangrur <u>U.P.:</u> Agra, Mathura
3. Western U.P. Wheat Sugarcane Area 12 Districts	Bareilly, Bijnor, Moradabad, Rampur, Shahjahanpur, Pilibhit, Kheri, Dehradun, Meerut, Muzaffarnagar, Saharanpur, Nainital
4. South-Central U.P. Wheat-Bajra Area 13 Districts	<u>Aligarh</u> , Etah, Mainpuri, Etawah, <u>Kanpur</u> , Farrukhabad, Budaun, Barabanki, Hardoi, Lucknow, Sitapur, Unnao, Bulandshahar
5. East Central U.P. Rice-pulses area 16 Districts	Allahabad, Fatehpur, Bahraich, Gonda, Partapgarh, Sultanpur, Azamgarh, Faizabad, Basti, Deoria, Gorakhpur, Ballia, Ghazipur, Jaunpur, Varanasi, Rai Bareilly
6. S.E. U.P. Rice-grain 5 Districts	Banda, Jalaun, Jhansi, Mirzapur, Hamirpur
7. A.P. Coastal 7 Districts	<u>E. Godavari</u> , Guntur, Krishna, Nellore, Srikakulam, Vishakhapatnam, <u>W. Godavari</u>
8. Tamilnadu Coastal 7 Districts	Chingleput, Kanyakumari, N. Arcot, Ramanathapuram, <u>Thanjavur</u> , Tirunelveli, S. Arcot

Appendix 3 (continued)

9. Maharashtra-Mysore Coastal
6 Districts
Maharashtra: Kolaba, Ratnagiri, Thana
Mysore: Coorg, N. Kanara, S. Kanara
10. East-Central Mah. Black Soils Area
10 Districts
Akola, Amravati, Bhandara, Buldana,
Jalgaon, Nagpur, Nanded, Parbhani,
Wardha, Yeotmal
11. West Central Mah.
Jowar-Pulses-Bajra
13 Districts
Mah. Ahmadnagar, Kolhapur, Nasik,
Osmanabad, Dhulia, Poona, Aurangabad,
Bhir, Sangli, Satara, Sholapur
Mysore: Bidar, Gulbarga
12. Northern Mysore Black Soil
6 Districts
Belgaum, Bellary, Bijapur, Chitradurga,
Raichur, Dharwar
13. Interior A.P. Jowar Red Soils
14 Districts
Andhra: Adilabad, Anantapur, Chittoor,
Cuddapah, Hyderabad, Karimnagar,
Khammam, Kurnool, Mahbubnagar, Nalgonda,
Medak, Nizamabad, Warangal
Mah. Chanda
14. Southern Mysore-Tamilnadu,
Red Soils
13 Districts
Mysore: Bangalore, Chikmagalur,
Hassan, Kolar, Mandya, Mysore, Shimoga,
Tumkur,
Tamilnadu: Coimbatore, Madurai,
Nilgiris, Salem, Tiruchirapalli.

_____ IADP Districts.

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