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Labor in the Indian Agriculture Sector

(A Report to A.I.D.)

by

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Labor in the Indian Agricultural Sector: Abstract

This report summarizes research on three related aspects of change in the Indian agricultural sector from 1956 to the present. In part II of the paper, data on change in output at constant prices, inputs and residual productivity change are presented on a state basis. In addition, wage data from several sources are summarized on a current and "real" basis for 10 Indian states over the period. Both sets of data reveal changes, which have been observed but not heretofore quantified.

Part III of the paper summarizes investigations undertaken with the most recent micro-data available. Cobb-Douglas estimates of production elasticities are presented. In general, they show: (1) that scale economies do not appear to have emerged in the green revolution; (2) no support for the zero-marginal product of labor hypothesis in any of the data sets; (3) some evidence that hired labor has a higher marginal product than family labor, and (4) that fertilizer, seeds and irrigation have marginal products above prices. In the Punjab data set, implements and tractors have a high marginal product with bullock labor showing a low marginal product.

In addition to the Cobb-Douglas estimates, estimates of the elasticity of substitution between labor and non-labor inputs, based on a C.E.S. formulation are reported. These estimates are less than one, suggesting a long run elasticity of .6 to .7. A further experiment with a quadratic production function for data from the Punjab is reported. The marginal product estimates are similar to the Cobb-Douglas results. Pair-wise elasticity of substitution estimates suggest a relatively high (1.44) degree of substitutability between labor and tractors.

Part IV of the paper develops an analytical model designed to show the determinants of the demand for labor. In particular, the model stresses the effect of neutral and non-neutral technical change on the demand for labor. One of the key implications of the model is that the price and income elasticities of demand for the product are of great importance. In addition the elasticity of substitution is shown to be of considerable importance. Data from Indian states are utilized to "test" the major implications of the model. The correlation between wage rate changes and productivity gains noted in part II of the paper is, consistent with the predictions of the model.

A final discussion of some policy issues is included. It is argued that the most serious implications of current change, are not those associated with rapid expansion of machine use, or of a malfunctioning labor market *per se*. The seriously uneven regional pattern of productivity gains is seen instead as leading to a set of problems stemming from the increases in labor demand in some regions and substantial decreases in others.

Labor in the Indian Agricultural Sector

by

Robert E. Evenson

I. Preface

This report is basically a summary of three related papers in process:

1. Productivity Change in Indian Agriculture: Measurement and Explanation.

2. Producer Response to Change in Indian Agriculture.

3. Changes in Real Wages in Indian Agriculture.

It does not include all of the materials developed in the papers, especially in paper #1 where an attempt to identify the factors producing real productivity gains in the sector is made. It also does not include all of the estimates of producer behavior undertaken in connection with paper #2. The emphasis is on pulling together the available evidence about labor utilization in Indian agriculture during a period when the sector adopted improved production techniques.

Section II surveys the available census and survey data on employment and unemployment in the agricultural sector. Productivity indexes for each State in India are then developed and presented. These indices (developed in paper #1) are subject to some data limitations, but represent a major improvement over the land productivity data which have heretofore served as the only indicators of real efficiency gains in the sector. Wage data, by State and District for several years are then summarized and some simple comparisons with the productivity data are made. These two sets of data reveal patterns not generally recognized to date, at least in quantitative terms.

Section III is a summary of micro-evidence (based on paper #2) from individual farm data. The emphasis of the section is on measurement of the elasticity of substitution between labor and other inputs. Data from several household surveys are utilized and scale parameters and marginal product estimates are discussed as well as the elasticities of substitution.

Section IV develops some of the theoretical implications of changing technology on both the price of labor and the quantity demanded. A cross section-time series econometric formulation with State data is utilized to "test" the implications of the theory. A discussion of policy alternatives is undertaken in the final section.

II. Survey of the Data

In this section we will present data on employment, unemployment, wages and productivity. The data on unemployment, as will be noted, are very limited and will force us to rely heavily on wage data for influences about the effects of economic change on employment. We begin with Table 1 which summarizes Census data on the rural labor force for 1961 and 1971. First, a note of caution. The 1971 figures are provisional and comparisons should be made with care. The data on the number of female cultivator laborers are not comparable between the two years because of a change in the criterion for inclusion in the labor force. In 1971 the requirements were higher for inclusions in the labor force for all workers, but the main effect was on females. Respondents were required to first state their main occupational activity. If this was household work, they were considered non-workers. Secondary occupational activity was not considered in the 1971 Provisional data, as it was in 1961. As result women whose main

activity was household work, but who otherwise would qualify as workers were not included in the work force.

If we concentrate only on the data for male workers we can arrive at some pretty firm conclusions from the data. We note first, that the male labor force increased by only 15.25 percent over the decade compared with a population increase of 24.66 percent. Of course, we expect a slower rate of growth of the labor force than population because of the changing distribution of the population. Although the urban population grew faster than the rural population (37.8 percent to 21.8 percent), the male agricultural work force (cultivators plus agricultural laborers) grew faster than the male non-agricultural work force (19.8 percent to 6.9 percent). The major component of growth in the male labor force was quite clearly in the agricultural laborer category, which alone accounted for 14 million of the total labor force increase of 19.7 million. The number of male cultivator workers, (including unpaid family workers) increased by only 2.5 million or 3.9 percent (between 1951 and 1961, the male cultivator work force grew by 29 percent compared to a 17 percent growth in male agricultural laborers).

On the face of it, even allowing for some errors due to non-comparability, the data does not provide a basis for optimism regarding economic development prospects. One key indicator, the percent of the labor force in agriculture has increased from roughly 65 percent to 67.3 percent (males only) over the decade after having been roughly constant since 1920. Furthermore, within the agricultural labor force, the cultivator labor force has remained roughly constant, and the growth has occurred almost entirely in the "landless labor" category. The data on employment of women suggest a

Table 1

Indian Labor Force by Major States: 1961-1971

(In Millions)

	Cultivators				Agricultural Laborers				Non-Agricultural Work Force			
	Males		Females		Males		Females		Males		Females	
	1961	1971	1961	1971	1961	1971	1961	1971	1961	1971	1961	1971
Andhra Pradesh	4.65	4.77	2.83	1.06	2.45	3.48	2.88	3.28	4.19	4.44	1.65	1.08
Assam	2.04	2.30	.99	.12	.15	.38	.02	.02	1.02	1.17	.53	.30
Bihar	6.93	7.14	3.44	.50	2.51	4.98	1.84	1.86	3.45	2.97	1.00	.56
Gujarat	2.82	3.18	1.70	.45	.68	1.23	.57	.63	2.19	2.65	.51	.30
Haryana	1.23	1.25	.60	.05	.16	.40	.04	.03	.73	.85	.11	.07
Kerala	.50	1.04	.27	.07	.52	1.18	.46	.71	2.53	2.47	.95	.69
Madhya Pradesh	5.93	6.54	4.68	1.57	1.40	2.21	1.42	1.89	2.65	2.80	.85	.55
Maharashtra	4.75	4.89	3.99	1.68	2.11	2.91	2.40	2.53	4.80	4.89	.90	1.01
Mysore	3.75	3.60	2.96	.49	.88	1.66	.88	.98	2.39	2.86	.76	.70
Orissa	3.19	3.22	1.17	.15	.81	1.53	.50	.40	1.34	1.36	.67	.28
Punjab	1.47	1.66	.13	.01	.32	.77	.02	.01	1.39	1.35	.13	.09
Rajasthan	4.21	4.57	2.80	.70	.22	.53	.16	.22	1.71	1.91	.43	.36
Tamil Nadu	4.23	4.01	2.23	.66	1.45	2.78	1.38	1.61	4.43	4.83	1.64	1.18
Uttar Pradesh	14.30	14.65	4.13	1.23	2.04	4.20	1.23	1.30	6.14	5.94	1.02	1.07
West Bengal	3.89	3.86	.57	.14	1.45	2.82	.32	.43	4.70	4.81	.65	.55
All India	66.42	68.97	33.11	9.74	17.32	31.31	14.20	16.00	45.37	48.51	12.15	9.08

Source: Census of India 1961, 1971 (Provisional)

sharp decline in participation rates except in the agricultural labor category.

It would be possible to read this evidence as supporting the view that the Indian economy is in serious difficulties stemming from (1) rapid growth of the labor force, (2) the inability of the non-agricultural sector to 'absorb' or demand labor at a rapid rate and (3) the failure of the agricultural sector to be transformed from a "labor surplus" to a modernized sector. Such a reading is unjustified in light of other evidence available, however. As we explore further data, it will become clear that real wages of agricultural laborers have risen over the decade, having fallen over the previous decade when labor force growth was slower. It will also be seen that productivity gains in some segments of Indian agriculture have been quite impressive.[1]

Returning back to Table 1, we should take note of the fact that the agricultural (landless) labor force does not dominate the work force in the agricultural sector. Even with the sharp increase to 1971, only 33 percent (up from 25 percent in 1951 and 21 percent in 1961) of the male work force in agriculture are landless. (Actually, the "landless" laborers are not strictly landless. In 1961, 39 percent of the agricultural labor households owned some land.) Kerala is the only state where agricultural laborers outnumber cultivator laborers. Labor force participation rates for women are difficult to ascertain, given the change in definition, but they are highest for agricultural laborers in both years.

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[1] It is widely recognized that a "green revolution" has taken place in India. Unfortunately, the popular conception of the revolution is quite misleading.

We turn now to the available evidence on unemployment in the rural sector. Table 2 summarizes the very limited data collected in the 1961 Census and in a series of National Sample Surveys. These data have come under such criticism that they are no longer being collected and we have no evidence at all since the 1966-67 survey. Much of the criticism [illegible] seems from the inherent difficulties in defining unemployment in the rural sector. The distinction between laborers and cultivators is arbitrary. In 1950, roughly 50 percent of the agricultural laborers owned some land and only 10 percent were "attached", that is worked on an annual basis for a cultivator household with the bulk of their wage payments being paid in kind. By 1957 the percentage of attached laborers had fallen to 2[illegible] percent, but 43 percent owned land and as a group [illegible] laborers were still employed 40 working days a year and employed for wages 157 days per year. Conversely, cultivator households [illegible] have substantial earnings from other farm or non-farm employment.

To begin, the demand for labor in the rural areas is seasonal. Almost everyone acknowledges that there is little or no unemployment in the peak harvesting season for most crops.[2] This is in strong contrast to a highly structured industrial labor market where workers tend to be either fully employed or fully unemployed. In addition there is a widespread belief that even when people are nominally "employed", they are really underemployed in that their marginal product is below the wage rate.

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[2] This is reflected in the N.S.S. data where higher rates of unemployment are observed in the March-June period part of which falls after the harvest of winter crops.

Table 2

Measured Unemployment, Rural India

Source and Date	Unpaid Family Workers as Percent of Workforce	Percent of Workforce Working Less than 28 hrs. per week		Percent Unemployed of Rural Population			Percent Unemployed of Rural Workforce		
		M	F	M	F	T	M	F	T
1. N.S.S. 4th Round April 1952-Sept. 1952						.05			
2. N.S.S. 6th Round May 1953-Aug. 1953	37.0					.50			
3. N.S.S. 7th Round Oct. 1953-March 1954	30.3					.21			
4. N.S.S. 9th Round May 1955-Nov. 1955	25.5					.29			
5. N.S.S. 10th Round Dec. 1955-May 1956	25.6					.87			
6. N.S.S. 11th and 12th Rounds Aug. 1956-Aug. 1957	24.5					1.44			
7. N.S.S. 14th Round July 1958-June 1959	29.4	5.78	8.94	1.48	1.94	1.71	2.69	4.18	3.43
8. N.S.S. 15th Round July 1959-June 1966		5.46	9.08	1.43	1.82	1.62	2.32	2.46	2.39
9. N.S.S. 16th Round July 1960-June 1961		3.84	6.55	1.44	1.80		2.59	6.49	
10. 1961 Census				.29	.03		.50	.10	
11. N.S.S. 17th Round Sept. 1961-July 1962		3.96	5.89	1.95	1.89		3.74	1.89	
12. N.S.S. 21st Round July 1966-June 1967							1.82	4.35	

Source: Dantwala Committee Report

The difficulties associated with a market with seasonal demand, high costs of search, and a mixture of wage and self employment which characterize most agricultural labor markets present a formidable set of obstacles to measurement of unemployment. Add to this, the desire to measure "underemployment" and it is little wonder that India has more or less given up its measurement activities for the present. Actually, the most potent criticism of the estimates in Table 2 is probably that they do not square with the pre-conceived notions of what they "ought" to show. The "zero or low marginal product" school expects high rates of unemployment on the grounds that unemployment and underemployment are likely to be highly correlated. The international "employment" school expects unemployment rates to be high and rising in all developing countries, as labor forces grow more rapidly.

The data in Table 2 have their limitations, of course. They are not [illegible] meaningless, however, as some critics would argue. They show higher rates of unemployment for women, for example, a very plausible result. The change in levels after the 10th round is the result of a more stringent requirement for being classed as employed (at least one hour of work on the reference day). After the 14th round the data seem to be pretty consistent. They show no obvious trend in unemployment over time. The N.S.S. surveys also measured employment in terms of hours per week and days per week. While a small percentage of the "employed" worked less than 28 hours per week, the average number of hours worked was 41.2 (days 5.94) in the 14th round survey (1959). It rose to 43.0 (days 6.30) in the 16th round (1961) and in both surveys no other occupational category had higher averages.

In the absence of unemployment data after 1966, we do not have a basis for directly judging the validity of the widespread view that a large amount of unemployment currently exists. Certainly the available data does not suggest that unemployment was high and rising up to 1966.

Unemployment data do not reveal very much about the market forces affecting labor and its price. We do have data on wages of agricultural labor, and some limited data on earnings of cultivator households. Utilizing these data, we get a very different picture of the Indian labor market experience than afforded by the census data and the institutional approach of labor surplus and related models.

From a demand for labor perspective, it is plausible for the share of the work force in agriculture to increase and for real wages to rise in the agricultural sector, relative to the non-agricultural sector. If real productivity gains are more rapid in agriculture and if the demand for the output of the sector is relatively price elastic, the demand for all factors in the agricultural sector will increase more rapidly than in the non-agricultural sector. Relative earnings will rise in agriculture, given inelasticities of supply of labor, spatially and occupation-wise. The data to which we now turn indicate that the earnings of agricultural laborers have risen in real terms relative to non-agricultural workers, and that in all probability productivtyy gains have been much higher in the agricultural sector. A formal treatment of the model and a further examination of demand factors is deferred to Section IV.

In Table 3, we present productivity data for 10 of the 14 major states in India. The presentation is in terms of rates of growth of output and measured inputs for three time periods. The "residual productivity" growth is the standard total factor productivity measure. In these data, as with most data of this sort, measured input growth "explains" only part of output growth, especially in the third period, 1963-66 to 1969-71. The "green revolution" period.

The input measure is a divisia index of changes in input quantities. The shares of each input component, are the divisia weights. This measure is based on factor payments equal to marginal products, a proposition that is usually questioned in Indian agriculture. A breakdown between the contribution of "traditional inputs" (labor, land bullock labor and traditional implements) and "modern inputs" (fertilizer, irrigation and tractors and improved implements) is made in the table.

I basically subscribe to the position that output growth in principle can be "explained" or accounted for in large measure. One could improve the conventional measures of inputs by making certain quality adjustments, for example. The input "weights" are probably incorrect, in that the marginal products of fertilizer and other modern inputs may exceed their prices by a substantial margin.

On the other hand, the "residual" can be informative, certainly more so than the output, per unit land measure currently used as a productivity indicator in India. Output per unit of conventional input is especially meaningful in measuring the shifts in production functions based on the rapid introduction of technology of the green revolution type. The use of consistent definitions of inputs and of regional prices should enable comparability among states.

Table 3

Growth in Agricultural Output and Inputs in Selected Indian States

1953-54 to 1970-71

STATE	1953-6 to 1958-61		1959-61 to 1963-5		1963-5 to 1969-71	
Andra Pradesh						
Annual Output Growth		2.42		2.63		-.24
Annual Input Growth		1.57		2.52		1.29
Traditional Inputs	1.48		1.09		.18	
Modern Inputs	.09		1.41		1.11	
Residual Productivity Growth		.85		.11		-1.05
Bihar						
Annual Output Growth		3.43		2.36		1.57
Annual Input Growth		2.03		2.04		2.39
Traditional Inputs	1.83		1.68		1.58	
Modern Inputs	.20		.36		.81	
Residual Productivity Growth		1.40		.32		-.82
[illegible]						
Annual Output Growth		2.00		4.71		7.13
Annual Input Growth		2.26		1.90		2.35
Traditional Inputs	1.83		1.16		1.62	
Modern Inputs	.43		.74		.73	
Residual Productivity Growth		.74		2.81		4.78
Haryana						
Annual Output Growth		4.73		1.23		20.40
Annual Input Growth		2.32		1.93		4.30
Traditional Inputs	1.15		.48		2.60	
Modern Inputs	1.37		1.45		1.70	
Residual Productivity Growth		2.41		-.70		16.10
Maharashtra						
Annual Output Growth		3.59		.85		.08
Annual Input Growth		1.48		1.78		2.21
Traditional Inputs	1.36		1.34		1.46	
Modern Inputs	.22		.44		.75	
Residual Productivity Growth		2.11		-.93		-2.13

Table 3 continued

Mysore	1953-5 to 1958-61		1958-61 to 1963-5		1963-5 to 1969-71	
Annual Output Growth		3.97		2.96		1.93
Annual Input Growth		2.94		2.27		1.66
Traditional Inputs	2.79		.75		.28	
Modern Inputs	.15		1.52		1.34	
Residual Productivity Growth		1.03		.69		.27
Punjab						
Annual Output Growth		4.73		3.60		19.20
Annual Input Growth		2.32		3.08		5.80
Traditional Inputs	1.32		1.28		2.64	
Modern Inputs	1.00		1.80		3.16	
Residual Productivity Growth		2.41		.52		13.40
Tamil Nadu						
Annual Output Growth		4.48		1.77		3.08
Annual Input Growth		3.49		3.94		3.27
Traditional Inputs	2.91		1.26		1.04	
Modern Inputs	.58		2.68		2.23	
Residual Productivity Growth		.99		-2.17		-.13
Uttar Pradesh						
Annual Output Growth		1.87		2.47		4.89
Annual Input Growth		1.44		1.81		1.96
Traditional Inputs	1.06		1.13		.76	
Modern Inputs	.38		.68		1.20	
Residual Productivity Growth		.43		.66		1.93
West Bengal						
Annual Output Growth		.36		4.66		2.18
Annual Input Growth		2.48		1.99		2.54
Traditional Inputs	2.37		1.56		2.49	
Modern Inputs	.11		.43		.05	
Residual Productivity Growth		-2.12		2.67		-.36

Turning to the actual data we find that growth in output has varied substantially over time and among states. In the first period 1953-1961, we find that 7 of the 10 states achieved output growth in excess of 3 percent per year. Only West Bengal had an unusually low rate. In the second period, the early 1960's, only 3 states (including West Bengal) achieved growth rates in excess of 3 percent. A clear slowdown in output growth is apparent. This shows up more clearly in the residual. Where 6 states had a one percent or more improvement in residual productivity in the first period, only 2 states achieved this in the second period.

The third period, 1963-65 to 1969-71 (the 2 drought years, 1965-66 and 1966-67 are not included in the data) is the period of the "green revolution". Wheat varieties from Mexico were introduced and major increases in output of this crop were achieved. Improved rice varieties, especially I.R.8 from the International Rice Research Institute were also introduced. It is clear from the table that major changes have taken place.

The states of Punjab, Haryana, and Gujurat and Uttar Pradesh have realized substantial gains in output growth and in productivity growth. The gains in the Punjab and Haryana have been extraordinary. It is unlikely that any agricultural region of comparable size has ever achieved an economic performance of this magnitude in any period of 6 years. This growth is obviously related to the new wheats, but they are not the entire story. The performance of Gujurat especially reflects the gains realized in sorghum and maize production.

The performance of the states of Andra Pradesh, Bihar, Maharastra, Tamil Nadu and West Bengal during the most recent period is in sharp contrast to

that of the first group of states. Residual productivity actually decreased in these states. None of the states dominated by rice production performed well during the most recent period. The green revolution simply has not occurred there. The pattern that was generally emerging in the early 1960's appears to have continued into the late 1960's. Productivity gains have slowed and become negative.

The data do show that the "modern" inputs are generally increasing in importance over time. In almost all cases their relative contribution to input growth is much greater than their share of total cost.

We turn now to wage data. Table 4 summarizes data from the most comprehensive source available. Wages reported are averages for the state computed from monthly reports from selected villages in most districts in the states. Only those villages reporting in all periods are included. The wages are for male field laborers and for carpenters. The carpenters are relatively highly skilled laborers in the village economy. Real wages are deflated by the official index of consumer prices paid by agricultural laborers for each state.

The data for the same 10 states as the productivity data show quite clearly that the widely held view that the wages of agricultural labor have not risen in the green revolution period are incorrect. Wages were higher in real consumer purchasing power in 7 of the 10 states in 1971 than in 1961. In the case of the Punjab wages were roughly 40 percent higher. The bulk of the increase occurred after 1966. In fact wages fell in 6 of the 10 states from 1961 to 1966.

Table 4

Wages in Indian Agriculture: Selected States 1957-1971

State	Current Daily Wages (Rs.) 1957	1961	1966	1971	Indexes of "Real" Wages (1961 = 10) 1966	1971
Andra Pradesh						
Carpenters		2.57	3.08	4.35	92.6	98.8
Field Laborers	.87	1.26	1.79	2.62	110.3	121.4
Bihar						
Carpenters		2.84	3.71	4.34	78.9	74.0
Field Laborers	.91	1.20	1.66	1.99	83.3	80.0
Gujarat						
Carpenters		4.42	5.38	7.71	90.1	100.9
Field Laborers	.87	1.62	1.75	3.22	80.3	114.8
Haryana						
Carpenters		4.51	5.59	9.83	89.8	112.4
Field Laborers	2.01	2.52	3.34	6.55	96.0	134.1
Maharashtra						
Carpenters		3.22	4.74	6.70	97.5	108.4
Field Laborers	.87	1.33	2.07	2.99	103.0	116.5
Mysore						
Carpenters		2.44	3.01	3.94	78.7	85.7
Field Laborers	.84	1.57	2.11	2.62	85.4	88.6
Punjab						
Carpenters		4.46	6.09	12.11	98.9	139.2
Field Laborers	2.01	2.40	3.70	6.49	111.7	139.6
Tamil Nadu						
Carpenters		2.46	3.66	4.98	100.0	116.3
Field Laborers	.84	1.18	2.05	2.41	116.1	117.8
Uttar Pradesh						
Carpenters		2.69	3.77	5.64	84.8	114.5
Field Laborers	.92	1.31	1.73	2.59	80.2	107.6
West Bengal						
Field Laborers	1.43	1.80	2.49	3.05	91.7	82.2

Carpenter wages are considerably higher than field labor wages but rose less rapidly. In fact, clear cut increases are apparent in only 5 of the 10 states. It should be noted that real wages declined substantially over the decade in West Bengal and Bihar. The states of Orissa and Assam probably experienced similar declines and this surely represents a serious situation, especially in Bihar.

Figure 1 presents the seasonal pattern of wages for 8 of the states. The seasonal demand for labor in India has received little treatment in the literature. Seasonal unemployment is often viewed as a reflection of inefficiency and laziness rather than of climate and weather. The data in Figure 1 suggest that market forces are determining wages. Seasonal demand shifts under conditions of inelastic supply between sectors would yield the kinds of wage patterns observed. The inelastic supply of labor between sectors of the economy and between regions is plausible in light of costs of job search, of non-transferability of skills, and of costs of short and long term migration. The kinds of wage differentials across months within regions and across regions are difficult to attribute to "institutional" factors.[3]

We will return to the question of wage determination in a later section. Here we will simply note the positive correlation of wage changes and residual productivity growth. The general picture that emerges from the organization of these data is one of increasing regional disparity in economic performance in the agricultural sector. In some major regions economic performance has been

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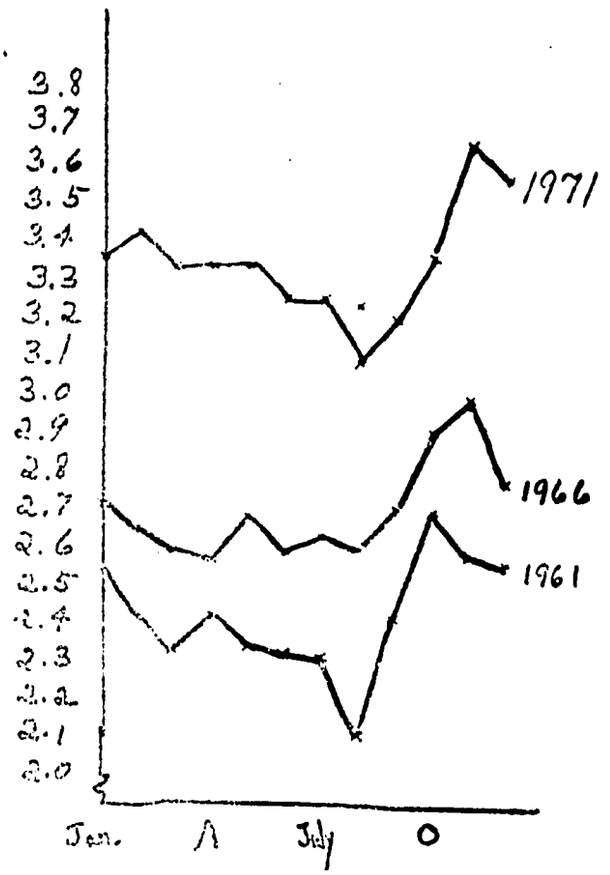
[3]The writers who hold the view that wages are institutionally determined have shown a high degree of imagination in shielding their formulations from testability. Some come close to saying that no conceivable evidence could be inconsistent with institutional wage determination.



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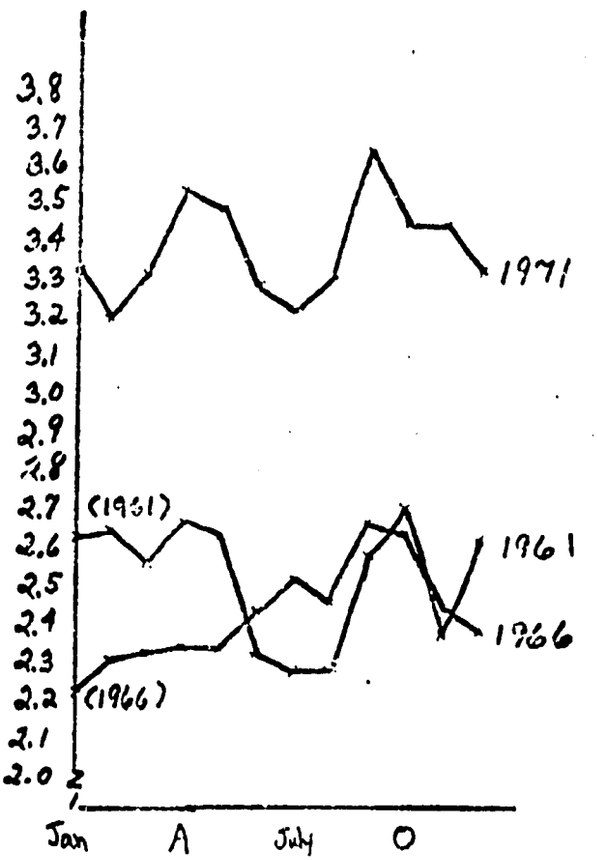

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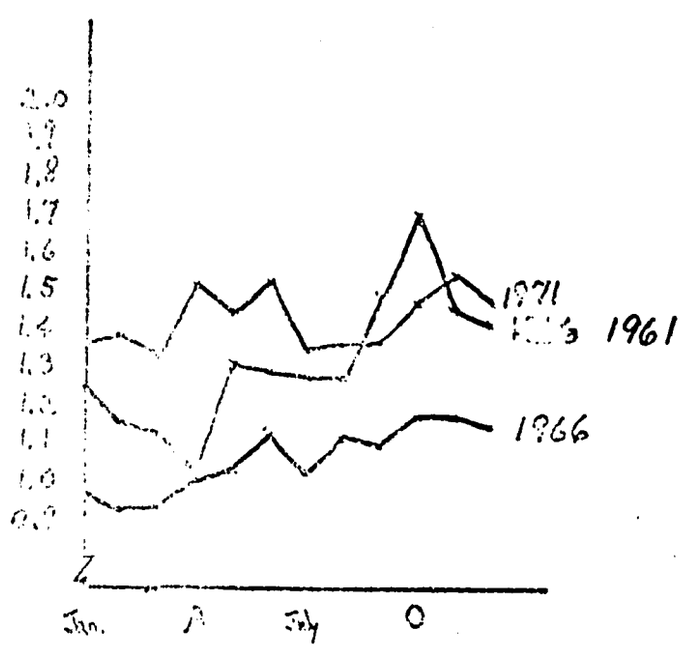

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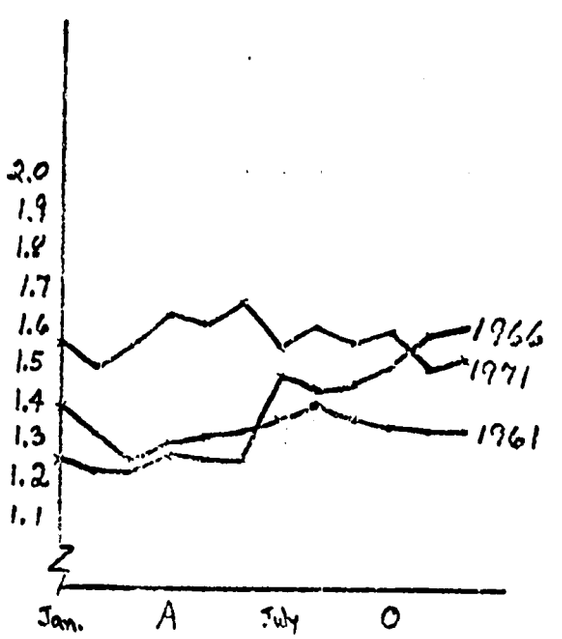

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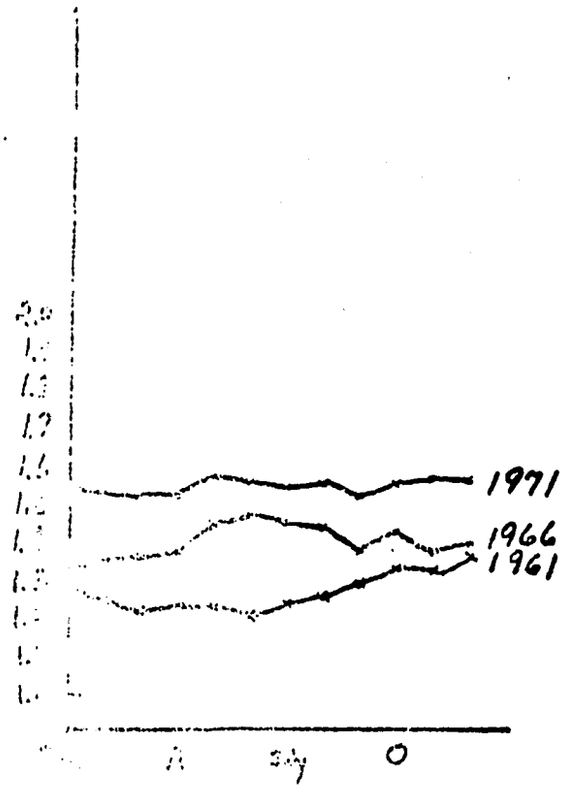

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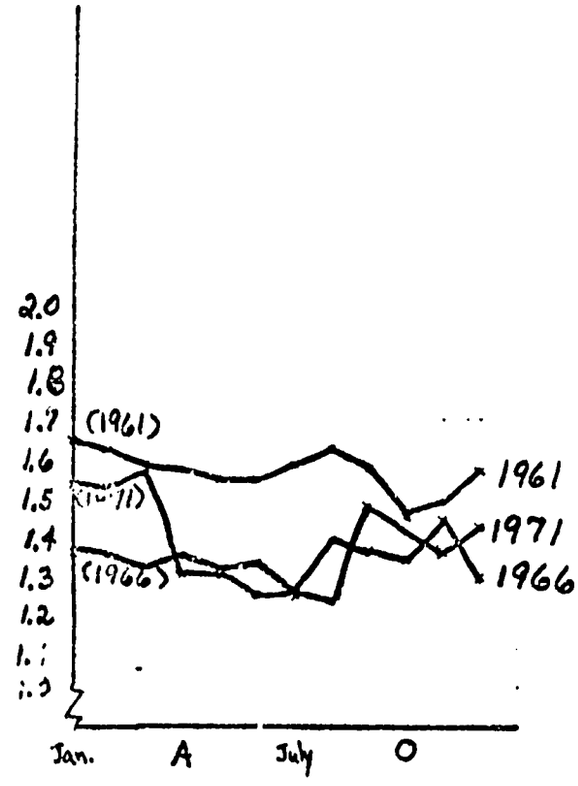

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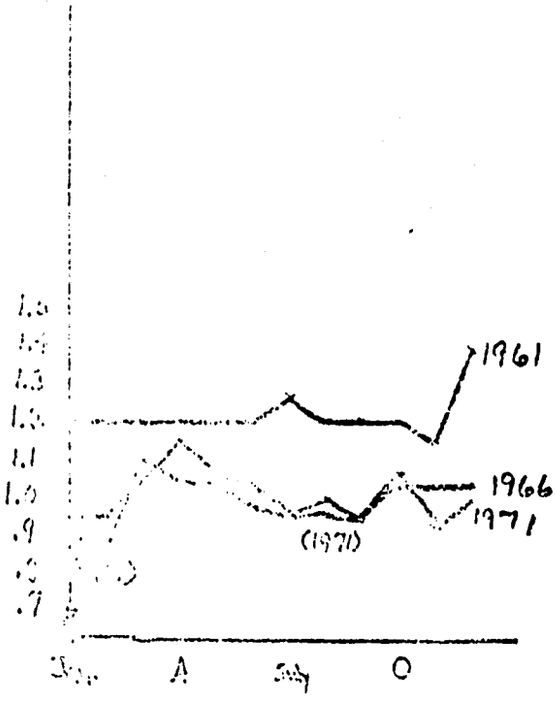

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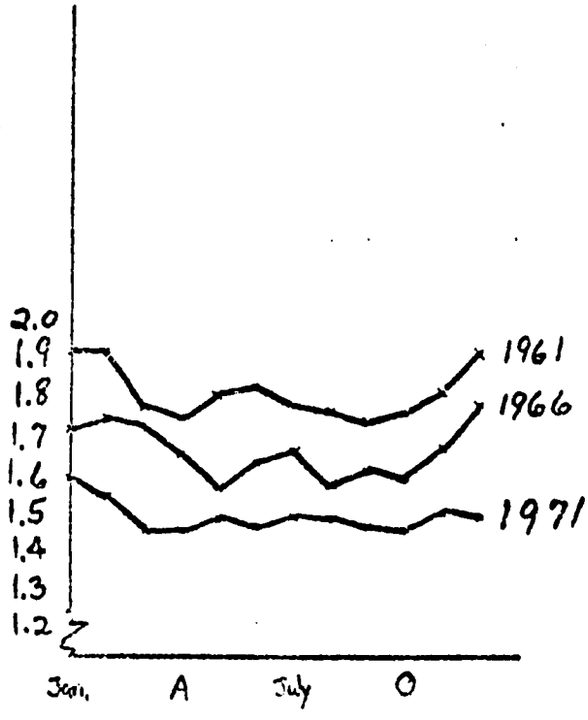

WEST BENGAL

extraordinary, in others dismal. Factor demand and factor payments are also showing increasing regional disparity.

III. Producer Response to Change

Data from producing farms can be useful for purposes of determining the effects of certain factors on the demand for labor. A number of data sets for Indian farms have been systematically collected by the Directorate of Economics and Statistics of the Ministry of Agriculture in India. These Farm Management Study data have been extensively subjected to analysis by many investigators [7, 9]. In general each data set has information for 150 farms from 10 or 15 randomly selected villages in a selected district. A sample of 10 or 15 farms stratified by size group is taken in each village.

Saini [9] reports the results of extensive work with these data sets from the 1954 to 1961 period. His conclusions regarding these studies can be summarized as follows:

1. Very little evidence of scale economies is forthcoming from these studies. Using 25 sets of data from 12 sets of 150 farms, Saini reports that in 22 of the data sets, an inverse relationship (statistically significant in 18 cases) between output and size of holding exists.[1] That is output per acre is highest on the smallest farms. Estimates of the Cobb-Douglas scale parameter were obtained for all 25 sets of data. Four of the 25 sets yielded significant (.05 level) increasing returns to scale.

2. Cobb-Douglas estimates of the marginal value product of labor (at the geometric mean) in a detailed study of 4 of the sets of data (for Uttar Pradesh 1955-56 and 1956-57 and for the Punjab 1955-56 and 1956-57) were significantly greater than the wage rate. This was true when the data were

[1] The equation estimated was Log (output) = c + αLog (size of holding) + u.

disaggregated into 3 size classes and 3 classes based on the fraction of labor hired. The small farms tended to have only slightly lower estimated values of marginal products than the larger farms.

3. Estimates of the marginal value products of bullock labor from the same data were generally significantly below the hiring rate.

4. Generally the Cobb-Douglas form fit the data reasonably well, with R^2's above .75. The coefficients on individual inputs were not always significant, but the labor variable is generally statistically significant.

Table 5 presents Cobb-Douglas parameter estimates for 6 Farm Management Surveys from 3 states, Punjab, Uttar Pradesh and Tamil Nadu. Data from the two periods are not from the same sample of farms, but they are drawn from similar districts. An attempt to define variables in a generally consistent fashion was made. It should be noted that there are numerous ways to define each variable and that the results are sensitive to the definition. For example, the variable, Current Inputs is an aggregation of fertilizer, seeds and irrigation charges. As the table demonstrates, it is a significant variable in all regressions. Attempts to estimate separate coefficients for seeds, fertilizer and irrigation usually result in a negative coefficient for seeds or irrigation charges.

The table reports some experimentation with the most recent data. Regression 2 for U.P. (Muzzafarnagar district) yields a high and significant estimate of labor productivity, (roughly equal to the factor share) but a low estimate of animal power productivity. In Regression 3, hired labor is included as a separate variable, and a portion of family labor equivalent to the hours worked by bullock pairs is allotted to the animal power variable.

The resultant estimates make sense, as the share of hired labor is roughly equal to the estimated production elasticity. Regression 3 implies a lower marginal product for family labor than for hired labor and the aggregation of family and bullock labor makes good sense. Regression 5 also allocates family labor to the animal labor variable. In Regression 7 this procedure did not produce very meaningful results.

Overall, the regressions reported in Table 5 yield relatively limited information. They are quite consistent with factor share evidence for the region and for the samples. In all cases, labor is a significant variable. The implied marginal product of labor is approximately equal to the wage rate for hired labor, although in equations 3 and 7 the marginal product of family labor appears to be slightly below the wage rate. These results, as well as those surveyed by Saini [9] and reported by Rao [7] do not support the zero-marginal product hypothesis.[1]

The animal power variable is not as well behaved, except in the cases (Regressions 5 and 5) where a combination of family labor and animal power is made. In the Punjab, the negative and insignificant results are somewhat consistent with the fact that the Livestock Census for the number of bullocks used for work declined from 207,000 in 1961 to 160,000 in 1966. In the same period, tractors increased from 1250 to 3020. This shift away from animal power towards tractors is quite substantial. The farms in the sample could be utilizing some "excess" mechanical inputs as a hedge against breakdowns in the tractors. The adjustment process is not likely to be a very smooth one.

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[1] This hypothesis has been pretty much refuted by all hard evidence and surely has limited relevance in the LDC world today.

In all cases the fertilizer, seed, irrigation variable has a relatively high and significant estimated elasticity, and the implied marginal product is generally above the prices paid for these inputs. This again, is quite consistent with the experience with fertilizer in the U.S. (Griliches [4]). In fact the Punjab sample farms (very much a green revolution sample), utilize substantial amounts of fertilizer, but appear not to have reached equilibrium.

The definition of implements in Regressions 1 and 4 included some irrigation equipment and specific water charges were included in current inputs. As a result land elasticities are low. Other land elasticities are consistent with land shares based on cash rent imputed values. The increase in the land coefficient in the Punjab is consistent with factor share data for the state where the land share rose from .37 to .41 from 1960 to 1966.

While these results are quite plausible and reinforce the treatment of Indian production [illegible] as responsive to economic incentives, they are limited in a number of respects. The fact that the Cobb-Douglas function "fits" data [illegible] that the elasticity of substitution is approximately one. It does not [illegible] the proposition. The elasticity of substitution is an important parameter, especially in the mechanization issue. The issue is not an easy one to approach, however. The standard C.E.S. estimating procedures are subject to two problems. First, the elasticity of substitution is not likely to be equal between input pairs. Second, the substitution of factor price data for marginal products in the formulation effectively means that one is estimating a "price response" parameter, instead of a technical parameter of a production function.

TABLE 5

Cobb-Douglas Production Function Estimates:

Selected Samples of Farm Data

Data Set	No. of Observations	R^2	Estimated Production Elasticities (std. errors)				
			Labor	Animal Power	Current Inputs	Implements	Land
1. Uttar Pradesh 1966-67	150	.848	.461 (.076)	.021 (.018)	.251 (.053)	.167 (.063)	.087 (.064)
2. Uttar Pradesh 1968-70	399	.907	.400 (.058)	.035 (.051)	.191 (.030)	.071 (.020)	.382 (.034)
			Hir. L	Fam. L.			
2a. Uttar Pradesh 1968-70	399	.901	.066 (.018)	.147 (.041)	.116 (.053)	.240 (.029)	.090 (.021)	.391 (.036)
3. Tamil Nadu 1955-56	150	.856	.411 (.121)	.071 (.083)	.246 (.073)	.325 (.082)	.101 (.081)
4. Tamil Nadu 1967-69	300	.920	.293 (.053)	.282 (.049)	.136 (.030)	.061 (.020)	.479 (.036)
5. Punjab 1955-56	193	.861	.399 (.071)	.063 (.049)	.102 (.054)	.102 (.047)	.462 (.051)
6. Punjab 1967-69	299	.714	.218 (.117)	-.071 (.055)	.283 (.056)	.087 (.029)	.509 (.054)

Notes: All date from Four Management Surveys. Some observations eliminated for missing data. Year dummy variables included in samples with 2 years data.

In the absence of other reported investigations of the elasticity of of substitution in Indian agriculture, the coefficients in Table 6 may be of interest. They are estimates of elasticities of substitution between labor and non-labor inputs from 3 sets of data. The estimating equation is the simple C.E.S. relationship with a Nerlovian adjustment lag:

$$\log VA = a + \sigma \log \frac{W}{P} + (1 - \lambda)\ VA(-1) + u$$

where VA is value added per unit labor, W/P is the real wage rate.

A variable, production per hectare is included to control for different levels of technical competence by producers. This is an imperfect measure of this competence, but the failure to take this into account is also an imperfection. Fundamentally, these regressions are price response relationships. Producers are constrained in their response to prices by (1) their level of understanding of profit maximizing behavior, (2) their knowledge of technical constraints to substitution and (3) "real" technical constraints to substitution. The estimates in Table 6 are not estimates of "real" elasticities.

The estimated short run elasticities of substitution are well below one in all cases, and are not changed much by the addition of the production per hectare variable. The estimated "long run" elasticity for the U.P. data is approximately .6 and for the Punjab data it is .68. For Tamil Nadu, it is approximately .3. Regressions 2 and 3 include an interaction term, lagged value added times production per hectare. This is an attempt to test the hypothesis that the adjustment parameter, λ, is a fucntion of the level of technical competence. The negative coefficients suggest that the higher the technical competence the greater is the long-run price response relative to the short run price response.

It would be presumptious to claim that these results were more than exploratory. Cross-section data are not very robust for estimating price responsiveness and even where 2 years data exist as in the Tamil Nadu and Uttar Pradesh samples, the price variation is relatively low. In addition, there is a relatively short period for learning to take place and be revealed in producer behavior. The Punjab data are for a set of some 30 or so farms over a 10 year period. This is a small sample and the estimates are of low statistical quality, but they may be more realistic.

These results are consistent with a number of studies which indicate that the introduction of tractors and other modern implements has not to date affected employment in a major way. It should be noted however that a process of mechanization is underway in India. The number of work animals declined in many states from 1961 to 1966, (almost by 1/4 in the Punjab) and tractors are being rapidly sold. From 1966 to 1970 the stock of tractors in India increased from 54,000 to [illegible]. The Punjab-Haryana region is the most mechanized region with some [illegible] of all tractors in India. It should be noted however, that the increase from 196[illegible] to 1970 was pretty evenly distributed over the country. In fact every state in India at least tripled its stock of tractors in that period.

Of the several sets of farm data, only one has an appreciable number of tractors and modern inputs. This is the data set for Ferozepore District in Punjab state. THe Cobb-Douglas estimates for this set (Table 5) indicated an insignificant animal power elasticity and a highly significant implement and mechanical power elasticity. These results indicate that the adoption of tractors and of modern implements (threshers, drills and cultivators) is not

Table 6

C.E.S. Estimates--Farm Management Data

Data Set:	R^2	Estimated Coefficients (standard errors) Constant	Wage	Lagged Value Added	Yield Index	Lagged Value Added X Yield
1a. Tamil Nadu 1967-69	.52	.314 (.212)	.275 (.139)	.035 (.031)	.216 (.018)	
1b. Tamil Nadu 1967-69	.54	-.001 (.25)	.282 (.137)	.079 (.037)	.250 (.024)	-.0000017 (.000008
2a. Uttar Pradesh 1967-69	.28	1.50 (.239)	.339 (.191)	.528 .074		
2b. Uttar Pradesh 1967-69	.34	1.17 (.243)	.360 (.184)	.610 (.073)	.000076 (.000017)	-.000059 (.000010)
3. Punjab* Farm Accounts 1967-69	.09	5.25 (.35)	.491 (.28)	.275 (.139)		

* Includes size class dummies

Table 7

Estimated Pairwise Elasticities of Substitution: Punjab
Farm Management Sample 1968-69--Quadratic Production Functions

	Labor	Bullock Labor	Current Inputs
Bullock Labor	.41		
Current Inputs	.32	.84	
Mechanical Inputs	1.44	.87	.77

uneconomic, as is often alleged. The marginal product of implements is substantially in excess of rental values.

C.E.S. experiments with the data yielded results similar to those for U.P. in Table 6 (σ = .29 with formulation as in Table 6; σ = .5 from non-linear estimates). Another experiment, however, yielded some results. Instead of estimating price responsive substitution, a production function which does not utilize price data and which does not impose constraints on pair-wise direct elasticities of substitution was estimated. The estimated equation was the following quadratic form:

$$Q = \underset{(13)}{1495} - \underset{(2.6)}{.00026\,L^2} - \underset{(.15)}{.000097\,B^2} - \underset{(1.8)}{.00159\,I^2}$$

$$- \underset{(4.0)}{.016\,M^2} + \underset{(.5)}{.0006\,LB} + \underset{(5.4)}{.0045\,LI} - \underset{(.6)}{.0019\,BI}$$

$$- \underset{(.01)}{.000035\,BI} + \underset{(.13)}{.0011\,BM} + \underset{(4.7)}{.0224\,IM} \quad (R^2 = .612, 235 \text{ obs})^1$$

where L is human labor, B is bullock labor, I is seed, fertilizer and irrigation and M is machinery including tractors. All variables are per unit of land.

The equation does not fit as well as the Cobb-Douglas (R^2 = .73). It does however, allow estimates of pairwise (R.G.D. Allen) elasticities of substitution which are based on revealed technology as opposed to price responsiveness. The pairwise elasticities (based on regressions of factor ratios on estimated marginal product ratios) are presented in Table 7.

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1. t ratios in parentheses.

The estimated elasticity of substitution between labor and mechanical power and associated implements is quite high. It has important implications. The elasticity between mechanical power and bullocks is not as high as one would expect. Actually the marginal productivity of bullocks is poorly estimated. The current inputs, fertilizer and seed do not appear to be very substitutable for other inputs.

Marginal product estimates from the quadratic production functions indicate that bullock labor has a marginal product roughly 1/2 its wage rate, labor roughly 2/3 the wage rate and that both current inputs and mechanical inputs have marginal products well in excess of factor payments.

The Punjab Farm Accounts data (not the Farm Management data) collected by the Punjab Board of Economic Inquiry enable a comparaion of the same 29 farms, over time from 1961-69. These farms are classified as small, medium and large and Table 8 summarizes expenditures for seed, fertilizer, and irrigation. These data as well as the data from the Farm Management Studies do not bear out the contention of many that small farmers lag in the use of modern inputs.

The same set of data show that days per annum worked by all farm workers increased from 196 in 1956 to 295 in 1968. Hours per day also increased (from 4.35 to 6.46). A number of the farms in the sample were using tractors.

A final set of micro data collected from 100 "progressive" farms in the Punjab is presented in Table 9. These data suggest that the main substitution of tractor hours has been for bullock labor instead of labor. Of course this is a rather special set of farms.

Table 8

Punjab Individual Cost Holdings Data (1961-1969)
Expenditure Data on Individual Farms

	1969	1968	1967	1966	1965	1964	1963	1962	1961
Expend per acre SEED (Rs.)									
Large	42.0	33.3	33.9	2[illegible].9	22.6	23.1	14.9	17.5	14.9
Medium	52.4	13.5	34.6	2[illegible].8	21.5	18.7	13.9	13.4	14.7
Small	92.3	85.1	70.6	43.1	71.0	37.0	23.5	23.4	14.1
Expend per acre FERTILIZER (Rs.)									
Large	84.7	64.5	40.3	27.9	25.1	30.1	16.3	15.8	12.7
Medium	90.7	77.[illegible]	53.5	3[illegible].9	27.9	21.7	11.7	19.0	14.5
Small	112.5	65.7	44.7	40.2	61.8	37.4	26.6	22.9	24.2
Expend per acre WELLS & TKR (Rs.)									
Large	38.5	18.0	9.1	[illegible].2	9.3	8.8	7.4	6.6	2.6
Medium	49.1	30.8	34.7	1[illegible].4	13.8	17.3	19.9	13.4	16.3
Small	59.9	35.4	30.0	1[illegible].4	17.3	25.9	31.8	35.3	23.1
VALUE OF OUTPUT per acre (irr)									
Large	1095.1	913.7	716.7	513.1	443.8	504.3	353.0	410.9	438.4
Medium	1020.8	1051.3	947.4	535.3	484.1	400.4	351.6	292.3	345.6
Small	976.7	1136.7	833.4	521.2	470.6	507.5	452.5	345.3	367.8

*Source: Board of Economic Inquiry, Punjab, Farm Accounts in the Punjab, Publication No. 117, 1969-1971, Chandegarh

Table 9

Changes in Farm Labour, Bullocks and Tractor Use in Punjab based on a sample of progressive farms in Punjab*

Year	Average Acreage Cultivated	Average Acreage Cropped	Intensity of Cropping	Total Labour Used (M. Hours)	Labour Used per cultivated acre (M. Hours)	Labour Used per cropped acre	Bullock hours used per cropped acre	Tractor hours used per cropped acre
1966-1967	33.19	42.05	126.69	11481	346	273	127.53	11.94
1967-1968	33.87	44.73	132.06	13821	408	309	76.15	9.58
1968-1969	36.85	49.89	135.39	16310	443	327	48.4	12.72
1969-1970	36.78	53.06	144.26	18145	490	342	35.66	17.24

*From the files of Department of Economics and Sociology, Punjab Agricultural University, Ludhiana.

On balance, the micro data surveyed here are consistent with economic responsiveness of farmers. Some apparent long run disequilibria exist in that it appears that the "modern" inputs have marginal products above prices. Labor certainly has a positive marginal product which is probably not too far out of line with the wage rate. No evidence of economies of scale is apparent.

IV. Real Wage Determination

One of the central issues in "employment" policy discussions is the effect of improved technology on labor use. Another is the extent of labor displacement when wages rise relative to other factors of production. In this section these two questions are analyzed with the aid of a simple model based on factor market equilibrium. It should be noted that the model does not imply that long run equilibrium will be quickly attained, nor does it imply that equilibrium will be obtained between the agricultural labor market and the non-agricultural labor market. It is based on the existence of market forces derived from profit maximizing behavior by farmers.

A substantial amount of the development literature has been founded on the existence of an institutionally determined wage in the agricultural sectors, presumably related to a "subsistence" level. While there is evidence that the sharing arrangements within families may be quite complicated and based on concepts of equity, this literature does not imply that market forces are unimportant. Sharing arrangements and family ties may affect the response to economic incentives in many families, but the high degree of labor mobility in India indicates that a great deal of response takes place.

The Cobb-Douglas estimates reported in this paper as well as a substantial body of supply response literature supports the contention that market forces are important in the agricultural labor market. The "surplus labor" models are not designed to examine the issue of institutional wages. They merely postulate it, largely because it is required to yield interesting results.

By and large these models are outdated and certainly so in the Indian case. Not only have real wages in the agricultural sector risen in certain regions, they have risen relative to non-agricultural wages and have actually drawn labor into the sector.

Unemployment in Indian agriculture certainly exists, but most of it is probably seasonal. Likewise, underemployment exists, but unfortunately most practical definitions of it are misleading. For example, if one defines underemployment as the labor actually used in excess of that required if all farms performed as, say the top 25 percent, we find that an economy like the U.S. probably has considerably more underemployment than India. This is simply due to the lag in adjustment to rapid economic change. The determination of norms against which to measure unemployment is extremely difficult.

In the model employed here unemployment and underemployment are not explicitly considered. It is possible to associate unemployment with market adjustment however and we would expect decreases in demand for labor in a particular region to lead to an increase in unemployment (and underemployment). This is largely a function of the relative size of labor flows required to reach equilibrium.

We start with a simple aggregate production function for agricultural goods:

1) $Y = T\,F(L,K)$

where Y is aggregate output, L is labor, for the time being assumed to be homogeneous, and K is the aggregate of non-labor factors of production. T is an index of productivity. Shifts in T are neutral in that the ratio of marginal products of L and K are unchanged. Production is subject to constant returns to scale (a reasonable statement for India), hence;

$f = Lf_\ell + Kf_k$, where $f_\ell = \frac{\partial f}{\partial L}$ and $f_k = \frac{\partial f}{\partial K}$. Also, $\sigma = \frac{f_k f_\ell}{f\ f_{\ell k}}$.

Now we first suppose that the demand for Y is perfectly elastic at $P_y = 1$, and that the supply of K is also perfectly elastic. The marginal conditions are:

2) $P_\ell = Tf_\ell$

3) $P_k = Tf_k$

Solving for equilibrium, we obtain:

4) $$\frac{\dot{E}P_\ell}{ET} = \frac{\partial P_\ell}{\partial T} \cdot \frac{T}{P_\ell} = \frac{1}{S_\ell} = \frac{EL}{ET}$$

That is, the elasticity of the price (and demand for) of labor with respect to a change in technology is simply the reciprocal of the share of labor in total costs. This result is straightforward. A one percent increase in productivity has the initial effect of reducing average costs by one percent. To reattain equilibrium, producers will increase output and will bid up the price of labor until average costs rise by one percent. Since the price of non labor inputs will remain constant and product price will not fall, this requires an increase of $\frac{1}{S_\ell}$ percent in the price of labor.

This case is the most favorable one for labor in the presence of productivity change. It is not as unrealistic as it might seem for many situations. A country importing substantial food grains faces a very elastic demand for agricultural products. Likewise, imported inputs such as tractors and fertilizers may have very elastic supply functions. Of course land is inelastic in supply but irrigated land may not be. In the case of a small region in a large country (as Punjab-Haryana) the initial effects

of productivity gains may not be too badly approximated by this simple model. If the marginal product of labor is less than the wage rate by some factor $d < 1$, the elasticity is lower by a factor d.

It is easy to extend the model to allow the supply elasticities of K and L to vary. The expression for the elasticity then becomes:

$$5)\quad \frac{EP_\ell}{ET} = \frac{\sigma + \varepsilon_k}{\sigma + S_k\,\varepsilon_k + S_\ell\varepsilon_\ell} = \frac{1}{1 + \dfrac{S_k(\varepsilon_\ell - \varepsilon_k)}{\sigma + \varepsilon_k}}$$

where ε_k, ε_ℓ are the supply elasticities of L and K. Now we see that the elasticity of substitution enters the expression, unless the supply elasticities are equal in which case $EP_\ell/ET = 1$. In the case of the region of India affected by the green revolution (Punjab-Haryana-Gujarat-U.P.) we would expect ε_k to be less than ε_ℓ especially in the long run. This would imply that EP_ℓ/ET would be less than one and that K would increase in price more than L, in response to productivity change. Labor can migrate into the regions and would have an incentive to do so. In fact with a low short run elasticity of labor supply and a higher long run elasticity, one would expect wages to decline after some point.

The implications of this model for productivity gains in particular regions is of considerable significance. To see this somewhat more clearly we need to relax the assumption of a perfectly elastic demand. Let the demand function for agricultural products be:

$$6)\quad Y = \phi(P), \quad \eta = \frac{P}{Y} \cdot \frac{dY}{dP} < 0$$

The equilibrium conditions are:

7) $\varphi(P) = T\ F(L,K)$

8) $P_\ell = PTf_\ell$

9) $P_k = PTf_k$

Constraining factor market equilibrium (that is, staying on the factor supply curves) we have:

$$10)\quad \frac{EP_\ell}{ET} = \frac{-(\eta + 1)(\sigma + \varepsilon_k)}{\Delta}$$

where $\Delta = -\eta\sigma - \eta(S_\ell\varepsilon_k + S_k\varepsilon_\ell) + \varepsilon_k\varepsilon_\ell + \sigma(S_\ell\varepsilon_\ell + S_k\varepsilon_k)$ and Δ is positive, since $(-\eta)$ is positive. Also

$$11)\quad \frac{EP_\ell}{ET} - \frac{EP_k}{ET} = \frac{-(\eta + 1)(\varepsilon_k - \varepsilon_\ell)}{\Delta}$$

We now see that the elasticity of demand for labor with respect to technical change can indeed be negative. Its sign depends on the term $-(\eta + 1)$, and we can see that if the demand for agricultural products is inelastic, the price of labor will fall in response to a gain in productivity, (the fall will be greater the lower is σ). Most discussions of the impact of technology on employment ignore the demand implications. For small regions within a country and for small countries which either import or export substantial amounts of agricultural products, the demand effects may not be too serious. In the United States and most other developed countries for that matter, they have been extremely important. The price elasticity of demand for agricultural products is generally regarded to be well below unity (around (-.2, -.4) in most developed countries and the productivity gains in the sector have increased the

economic pressure to shift resources out of the sector. Of course over time population growth, income growth and income elasticities are important too, as we shall shortly demonstrate.

For the present India has been able to increase production substantially with little price decrease because of displacement of food imports, especially of P.L. 480 wheat from the U.S. A policy designed to achieve self sufficiency in food grains has been adopted, and the large output gains in several states have enabled substantial achievement toward this goal. As the goal is approached, India will almost certainly be experiencing price inelastic demand for food grains. When this occurs, the market forces will be in strong contrast to the experience of the past several years, where productivity gains in the sector have increased the demand for labor. India will then have the classic "farm problem" of the rich countries.

We now extend the model by introducing time rates of change. In doing so, we acknowledge that we are sacrificing some realism by introducing smoothness in productivity change and supply and demand function shifts. The real world does not change very smoothly. This can be minimized by applying the model to relatively short periods of time. We gain from the extension, in that we can integrate population change and other types of shifts into the analysis. Let:

12) $Y = \phi(P,t)$; $\eta = \frac{\partial\phi}{\partial P} \cdot \frac{P}{Y}$; $\frac{\partial\phi}{\partial t} / \phi = \dot{D}$, be the demand function for agricultural products.

13) $Y = T\,F(L,K)$; $\frac{\partial T}{\partial t} / T = \dot{T}$, be the production function, and,

14) $L = g(P_\ell, t)$; $\varepsilon_\ell = \frac{\partial g}{\partial P_\ell} \cdot \frac{P_\ell}{L}$; $\frac{\partial g}{\partial t} / L = \dot{L}^*$,

15) $K = h(P_k, t)$; $\varepsilon_k = \frac{\partial h}{\partial P_k} \cdot \frac{P_k}{K}$; $\frac{\partial h}{\partial t} / K = \dot{K}^*$, be the supply functions of labor and non labor inputs. Differentiating with respect to time and solving for $\dot{P}_\ell = \frac{\partial P_\ell}{\partial t} / P_\ell$ we obtain:

16) $\dot{P}_\ell = \frac{1}{\Delta} [(\sigma + \varepsilon_k)(\dot{D} - (\eta + 1)\dot{T}) - S_k(\sigma + \eta)\dot{K}^* - (S_\ell \sigma - S_k \eta + \varepsilon_k) \dot{L}^*]$

17) $\dot{P}_k = \frac{1}{\Delta} [(\sigma + \varepsilon_\ell)(\dot{D} - (\eta + 1)\dot{T}) - S_\ell(\sigma + \eta)\dot{L}^* - (S_k \sigma - S_\ell \eta + \varepsilon_\ell) \dot{K}^*]$

18) $\dot{L} = \dot{L}^* + \varepsilon_\ell \dot{P}_\ell$

19) $\dot{K} = \dot{K}^* + \varepsilon_k \dot{P}_k$

20) $\dot{Y} = S_\ell \dot{L} + S_k \dot{K} + \dot{T}$

21) $\dot{P} = S_\ell \dot{P}_\ell + S_k \dot{P}_k - \dot{T}$

We are now able to see the implications of exogenous shifts is the supply functions of factors, $\dot{K}^*$ and $\dot{L}^*$, and of demand, $\dot{D}$, on the demand for labor. Consider a rise in the non-agricultural wage rate because of productivity gains under conditions of elastic demand. This can be viewed as a leftward shift in the labor supply function to agriculture, i.e. as a negative $\dot{L}^*$. We can see from Equation 16 that this will increase $\dot{P}_\ell$. The increase will be greater, the greater are σ, S_ℓ $(-\eta)$ and ε_k (if $\dot{D} - (\eta + 1)$ is positive). A policy of improving information about non-farm job opportunities, or of subsidizing non-farm job skill acquisition will have the same effect. A public sector employment project will also shift the supply function of labor to the agricultural sector in this direction.

We can also see that the effect of a shift in the supply function of non labor inputs to the right ($\dot{K}^* > 0$) will depend on the sign of $(\sigma + \eta)$. If an implicit subsidy to tractor purchasers is given through subsidized credit, for example, this can be viewed as a positive shift in K^* and it will lower $\dot{P}_\ell$ if the elasticity of substitution is greater than the absolute value of the elasticity of demand. For a relatively small region of the country this is not likely to be the case even though we have estimated a relatively high elasticity of substitution in Punjab agriculture. For India as a whole it is probably not the case today while food grains are still being imported. As a result programs which subsidize mechanical imports are probably creating employment in India under present circumstances. If, however, India achieves self sufficiency, this will change and the same policies will reduce the demand for labor.

Growth in the labor force has two effects, one on supply functions, $\dot{L}^*$, another on the demand function, $\dot{D}$. The population elasticity of demand is probably less than one because the population is getting younger when it grows rapidly. By the same token the labor force grows at a slower rate than population.

The effect of $\dot{T}$, the rate of neutral technical change, on the demand for labor, as before, depends on the sign of $(\eta + 1)$. We now see that growth in demand $\dot{D}$, plays an important role. This term is roughly equal to the population growth rate plus the rate of change in per capita income, times the income elasticity of demand for agricultural products. Available estimates pretty well establish that the income elasticities of demand for most agricultural products are relatively low, especially at high income levels. This characteristic

of consumer behavior becomes particularly important at later stages in the development process. In a two sector model, the relative income elasticities of demand for agricultural and non-agricultural goods and the relative rates of productivity change govern the relative share of labor in the two sectors.

The importance of the elasticity of substitution is more readily seen in this model, especially regarding $\dot{K}^*$. When $\dot{D} = \dot{T} = \dot{K}^* = 0$ and when $\epsilon_k \to \infty$, we can solve for:

$$22)\quad \frac{\dot{L}}{\hat{P}_\ell} = \frac{E_\ell}{EP_\ell} = -S_k\sigma + S_\ell\eta$$

$$23)\quad \frac{L}{\hat{P}_k} = \frac{E_\ell}{EP_k} = S_k(\sigma + \eta)$$

These are the standard R.G.D. Allen [ ] results. The importance of σ and η in factor demand is readily apparent here. In both expressions a low σ works to the benefit of labor as it makes the own price elasticity lower and the elasticity of demand with respect to a negative change in the price of non-labor inputs is more likely to be positive.

We now modify the model to examine the effects of non-neutral technical change. Let the production function be:

$$24)\quad Y = F(\hat{L},\hat{K}) \text{ where}$$

$$25)\quad \hat{L} = T_\ell L;\ \dot{T}_\ell = \frac{\frac{\partial T_\ell}{\partial t}}{T_\ell}$$

$$26)\quad \hat{K} = \dot{T}_k K;\ T_k = \frac{\frac{\partial T_k}{\partial T}}{T_k}$$

Where T_ℓ and T_k are factor augementation indexes. The solution for $\dot{P}_\ell$ is now:

$$27)\quad \dot{P}_\ell = \frac{1}{\Delta}\,[(\sigma + \varepsilon_k)(\dot{D} - (\eta + 1)(S_\ell \dot{T}_\ell + S_k \dot{T}_k) - S_k(\eta - \varepsilon_k)(1 - \sigma)(\dot{T}_k - \dot{T}_\ell) - S_k(\sigma + \eta)(\dot{K}^* - \dot{L}^*) - (\sigma + \varepsilon_k)\,\dot{L}^*]$$

The direct effect of technical change on the demand for labor differs from the previous result only in that the technical change term is a weighted average of the augmentation indexes. An indirect effect is possible through the second term which shows the effect of non neutral change on factor ratios. We note that it is unimportant if $\sigma = 1$. If $\sigma > 1$, as estimated in the Punjab, relative capital augmenting change, $(\dot{T}_k > \dot{T}_\ell)$, will have an indirect negative effect on the demand for labor. The third term shows the effect of an exogenously changing factor share. The implications for $\dot{K}^*$ and $\dot{L}^*$ are as before.

We have not really dealt with regional shifts in technology with this set of models, but the intuitive extension is relatively straightforward. Consider 2 regions supplying the same market. One region realizes productivity gains lowering costs and leading to increased output. The market elasticity of demand is relatively high because the consumer market is served by both regions. The productive region realizes a net increase in demand for factors, and the prices of factors are bid up. Regional supply elasticities determine which factors gain most.

The effect on the unproductive region is essentially a leftward shift in the demand function. (The variable $\dot{D}$ shows what happens, e.g. in Eq. 27). Demand for factors declines and prices fall. Supply elasticities again determine who the biggest losers are. In the short run, labor supply functions between

the two regions are inelastic and a wage disparity emerges or worsens, increasing the incentives for migration. In the long run as migration occurs the wage disparity may be reduced and the dominant regional effects occur in the prices of immobile factors. This "Applachian" effect is presently taking place in India as productivity gains have been very regional.

This analysis of relative wage determination is probably unrealistic to some degree, but it has yielded some insight. We now turn to the wage and productivity evidence from India to see whether the experience of differential regional productivity gains and other factors are related to wage changes in state data. While we do not have data which enables an estimate of all of the parameters of Equation 27 or 16 we can estimate certain combinations of coefficients. That is, we can estimate the reduced form coefficients, but cannot identify the structural coefficients of the model. We have data on the rates of change in real wages for field laborers productivity and several other variables for 10 states and 3 time periods. Changes in carpenters wages are available for 9 states for 2 periods. The statistical quality of the results is not extraordinary, but given the nature of the data and of the model, they would appear to provide substantial support to the model. Manufacturing wage changes serve as a proxy for $\dot{L}^*$ in the model and the percent change in literacy has 2 interpretations. An increase in literacy implies a negative $\dot{L}^*$ since children are staying in school longer. In addition, it is associated with skill acquisition and labor quality improvement. Regressions 2 and 5 are most consistent with the model.

Table 10

Regression Analysis: Wage Rate Determination in 10 Indian States

Independent Variables	Field Laborer Wages: Dependent Variable			Carpenter Wages Dependent	
	(1)	(2)	(3)	(4)	(5)
	Standard errors in parentheses				
Constant	2.96	.89	2.89	-.06	1.66
(1) Rate of change in Total Factor Productivity	.31 (.10)			.19 (.10)	
(2) Elasticity of Total Revenue = % ΔTR/% Δ Prices	-.17			.42 (30)	
(3) (1) x (2)		.025 (.011)	.034 (.010)		.034 (.006)
(4) Rate of change in Wages in Manufacturing	.25 (.26)		.56 (33)		.20 (30)
(5) Change in percent literate	.29 (.17)	.22 (.17)	.21 (.19)	.26 (.12)	.20 (.13)
(6) Dummy Variable: Period 1 1955-1961		1.31 (1.01)			
R^2	.34	.30	.43	.71	.71
Number of Observations	30 (10 states, 3 time periods)	30 (10 states, 3 time periods)	18 (9 states, 2 time periods	18 (9 states, 2 time periods	18 (9 states, 2 time periods

V. Rural Employment Policy

A wide range of topics and issues have been subsumed under the general heading of "employment problems." To some writers, the term is simply a proxy for "economic development problems." To others, it means specific issues such as the proper measurement of unemployment or the size and functional distribution of income. Still others see it as a Keynesian aggregate demand problem. About the only common theme to the emerging literature in the area is that problems exist and that the "invisible hand" cannot be relied upon entirely for their solution. In view of the emphasis of this paper on market forces, it might be concluded that the author is willing to rely exclusively on the invisible hand. This is not the case, although it will be argued that government policies which ignore market effects are likely to be counterproductive.

Perhaps the over-riding characteristic of LDC's leading to a concern with the employment of labor is the historically high rates of new entry into the labor forces, occurring at the present time and expected to continue for some time. Johnston and Cownie [5], among others point out the alarming implication of growth rate arithmetic which requires an improbably high rate of growth of the non-agricultural labor force if the share of the labor force in agriculture is to decline. The rapid growth of the labor force is alarming, to the extent that it implies that real all-inclusive capital, human, reproducible and natural resource based, per capita will be lower than it might be with slower population growth. But, this says little about the efficiency of the labor market or the desirability of a particular share of labor in the agricultural sector.

The considerable evidence, that urban unemployment rates in many LDC's have risen in the past few years, of course, does suggest that labor markets are not functioning well. It does not follow, however, that the labor market within the agricultural sector must be failing to provide the price incentives required to guide adjustment. In fact, an economy achieving real productivity gains is almost certainly going to experience labor market proble

As discussed in Section 4 of this paper, the relative share of the labor force in agriculture is largely determined by demand factors over a long period. Falling shares of labor in agriculture are the result of relative rates of productivity gain in the agricultural and non-agricultural sectors and relative rates of growth in demand for the outputs of the sectors. The simplistic view that emphasis on productivity gains in the non-agricultural sector will lead to a declining agricultural share of the labor force is nonsense. Of course, equal rates of productivity growth in the two sectors will result in a falling agricultural share and in a set of adjustment problems associated with new skill acquisition, severing social relationships and the like.

The occupational change history of virtually all developed countries has been dominated by rural to urban migration and shifting to new occupations. In India, as we have noted, the past decade has been characterized by a rising share of labor in agriculture, although a substantial amount of rural to urban residential migration has taken place. The pattern of productivity growth in the agricultural and non-agricultural sectors under the demand conditions prevailing in India are consistent with the rising share. In addition, the evidence indicates that labor is being utilized

more days of the year and more hours per day in the most recent periods. This is particularly the case in the regions experiencing the most rapid productivity change.

It is fundamentally the case that the failure of the Indian industrial sector, and a good part of its agricultural sector, to achieve efficiency or productivity gains is its dominant problem. Continued failure to achieve productivity gains will mean that most current problems will worsen over the next decade.

The dominant current issues in the agricultural sector are not the threat of labor displacement by tractors or of other modern inputs, or underemployment per se. As we have shown in the previous section, under present demand conditions, subsidized mechanization is probably creating employment. Also, there is very little evidence to substantiate the underemployment case. The real issues are rather those connected with the uneven pattern of productivity gains and the regional disparities in factor prices stemming from them.

In the green revolution regions, the benefits of the productivity gains have been shared somewhat unequally by factor owners. Land owners have gained most, the providers of managerial inputs have also realized large gains, and the providers of labor have probably gained least. As we have noted, however, they have all enjoyed higher earnings. The sellers of labor services have probably gained more than indicated by the higher real wages, as they have been employed more days of the year and more hours per day.

In other regions of the country, the picture is very different. Real wages have fallen in Bihar and West Bengal. Little or no productivity gains in either sector have taken place. The owners of all factors have probably lost, with land

owners quite possibly losing most.[1] Days employed and hours employed have probably not improved in many regions. These "poor but efficient" regions have become poorer. Whether they are becoming less efficient is difficult to say.

Poor Applachian-type regions can be bailed out in several ways. (1) An expanding demand for labor in an alternative market can provide new jobs if the costs of occupational and residential migration are relatively low. (2) A "spreading" of the agricultuaal productivity gains from other regions to the lagging regions can take place. (3) Public sector employment, either legitimate or "W.P.A."-type can be provided.

Unfortunately, none of these routes is easy or cheap. India is taking some action on all three fronts, with most current emphasis on "W.P.A." programs. Rural development is emphasized as a long range program and some realistic planning appears to be underway. Decentralization of some Indian industry is probably feasible. Most importantly the productivity gains achieved to date provide important new markets for industrial products. This is especially true for farm inputs such as fertilizer and implements, and processing, storing, and marketing services for agricultural products. In addition, new consumer markets in many rural areas are opening up. Much of this new induced industry can be efficiently located in rural areas. Again, most of India's accomplishments on this score have taken place because of market forces instead of planned development. The thriving small scale industry sector in the Ludhiana area in the Punjab demonstrates that rural development is feasible, and that it is most likely to benefit the regions already well situated.

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[1] Actually, land prices will decline if product prices decline, but part of this may be offset by a Malthusian effect. Growth in the labor force can lead to an increase in the price of land.

The policies required to achieve productivity gains in the laggard regions are poorly understood, partly because development economists have given little serious attention to the topic. There is an emerging basis for policy guidance, however. At least, attention is being given to the agricultural research system and to the barriers to technology transfer between regions.[1] As the experience with U.S. agricultural productivity demonstrates, regionally concentrated gains (in the Corn Belt) can be "spread" to other regions (the South) given appropriate investment. We are now beginning to understand which investments are appropriate and that extension programs and community development programs cannot achieve this without solid research systems generating region-specific improved technology. India is now moving on this score, but very slowly. Of course, there are limits imposed by nature on what can be accomplished here. We in the U.S. did not completely solve our Appalachian problem via research and T.V.A. Out migration from the region was necessary

Public works projects, such as the CRASH scheme for rural employment instituted in India have a great attraction to policymakers. They are quickly implemented and highly visible. Funds can be disbursed to every region in the country enabling an expansion of the political power of government. In India, an almost frenzied effort has been made to implement a program which costs more than twice as much as the agricultural research system of the country. Virtually no real planning has gone into the projects and the program is not particularly concentrated in the laggard regions. At this point little

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[1] See Kisley and Evenson [5], Buttan and Jayani [8], Evenson [2] and of course Griliches [3] on hybrid corn.

evidence is available as to what has been produced by the effort.

Actually, the productivity gains in the sector, have the effect of raising the expected rates of return to investment in many public sector activities. It surely makes sense to undertake such investment. In such projects, the real social opportunity cost of labor will be low if labor which would otherwise be unemployed can be utilized. Projects in the advancing areas have probably become more feasible in the last few years and at private wage rates, one would expect the bulk of public sector investment to take place in these regions. In fact enlightened governments will undertake them without a wage subsidy. In the laggard areas, the social opportunity cost of labor is not necessarily zero. It is extremely difficult to devise a program where this would be so.

The 'bumping' argument, used in this context, is not a valid argument. The contention that a currently employed laborer hired on a public project will be replaced by a currently unemployed laborer is based on a very peculiar view of market behavior. It presumes that migration and job search costs are low and that laborers are relatively homogeneous in quality. In India, job search costs are probably very high, and virtually all studies of unemployment identify age-sex and schooling differences between the unemployed and employed.

It is probably too soon to judge the overall impact of the CRASH program. It seems unlikely, however, that placing emphasis on employment as opposed to optimum public sector investment policy is wise.

When Census data become available they will probably reveal a great deal of labor migration between districts and states in India, much of it rural to rural. It would appear that cultural factors are not a serious inhibition to migration. They may, in fact induce it in the sense that migration can be

the escape route from caste dominated rural soceity. The achievement of uinversal primary schooling, will surely place tremendous stress on the rural social and cultural institutions. This, along with the reasonable possibility that India will be able to expand non-agricultural employment to meet new rural consumer demands make it very likely that the next decade will witness a great deal of migration. This places a premium on public policies to efficiently provide job information, and to guide the location of new industries accordingly.

At present, little current information on unemployment is being collected and the popular concept of the levels of unemployment is largely created by the Indian press. The substitution of journalism for hard data collection is not a happy situation. The 1971 Census does not even attempt to measure rural unemployment. It is not an easy task and relatively few countries attempt it for various reasons. National Sample Surveys can presumably gather data on no. of hours and days employed in the past month. Village Surveys based on recall data for much longer periods and for for more complicated information appear to be reasonably accurate.

It is particularly important that a responsible source of information replace the irresponsible journalism, which is not so much a threat to incite revolution as it is to incite hastily developed and planned public programs. The business of measuring "underemployment" is really a different kind of problem, and it doesn't make sense to combine it with a measure of open unemployment.

The responses of the agricultural labor market in India to incentives provided appear to make economic sense. Some of the incentives may not, however. On the issue of mechanization, it would appear that for the present there is little basis for either subsidizing or penalizing machine use. The market

for machinery is there. Subsidies in the form of cheap credit have been reflected in the black market prices mainly. At the present stage, labor is not being displaced by machinery. The potential market for farm machinery is substantial, and the rising price of labor in the Punjab has already induced the growth of a substantial industry. The sale of tractors over the past several years will no doubt induce more.

The evidence available appears to indicate that neither multinational firms nor the government dominated firms in the input supply industries are particularly innovative. The innovations and development of "intermediate" technology are dominated by the small firms which have emerged pretty much in spite of the government planning activities. To kill off these industries under an "employment" policy would seem unwise.[1]

This brief discussion of policy issues can hardly pretend to do justice to the problems involved. It is intended as a policy extension of the analysis reported earlier. The scope for further investigation is tremendous.

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[1] The potential for development of the farm supply industries is reflected in Paul David's calculation that in 1906, the largest single industry in the U.S. was the farm machinery industry, [1].

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