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AGRICULTURAL DEVELOPMENT AND FARM EMPLOYMENT IN INDIA. (Foreign Agricultural Economic Report). / William J. Staub. Washington, DC: Economic Research Service. Jan. 1973.

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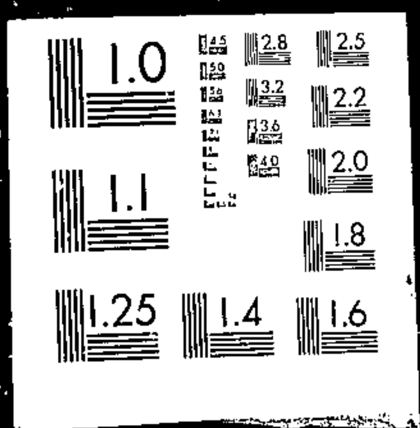
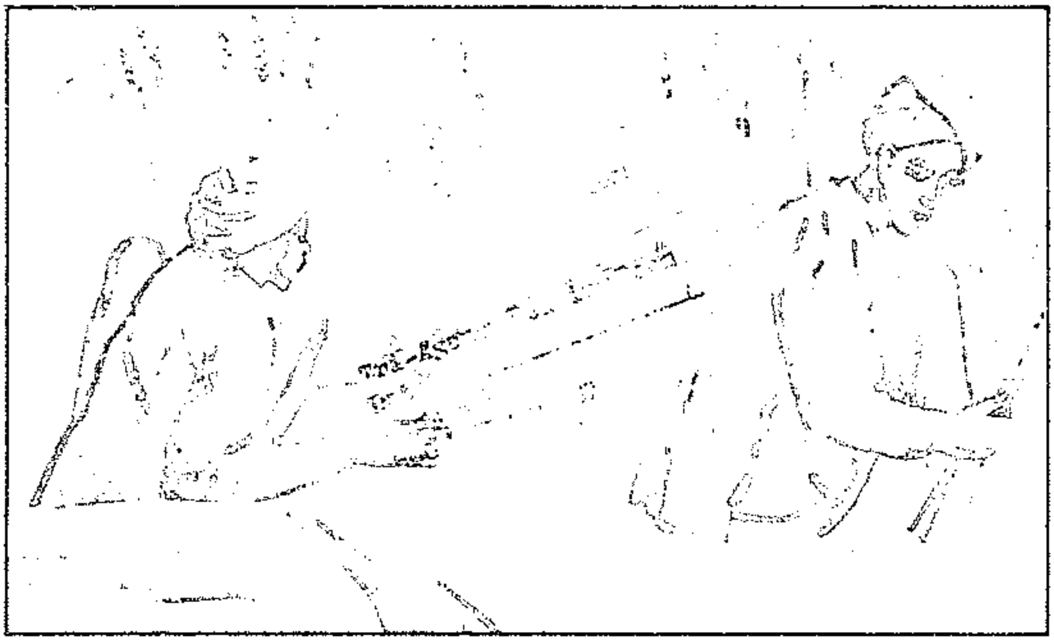
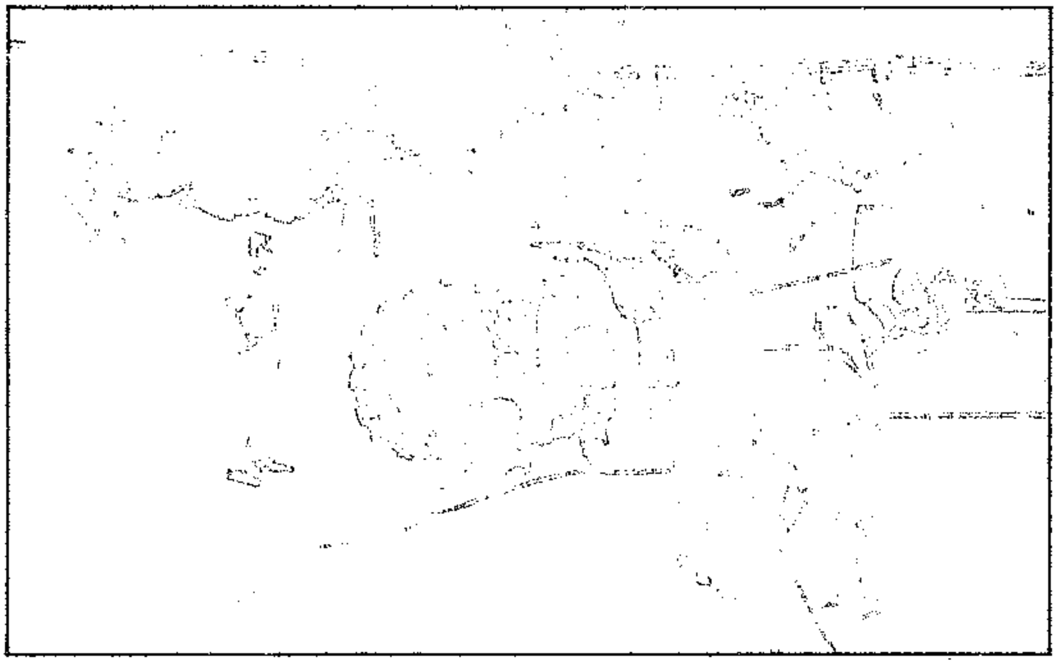


AGRICULTURAL DEVELOPMENT AND FARM EMPLOYMENT IN INDIA

FOREIGN AGRICULTURAL ECONOMIC REPORT NO. 84





ECONOMIC RESEARCH SERVICE ———— U.S. DEPARTMENT OF AGRICULTURE

ABSTRACT

Increased use of modern inputs (irrigation, seed, and fertilizer in particular) was positively related to the total amount of labor employed per farm in two districts of India where substantial increases in farm production have occurred. These inputs had a greater influence on the amount of hired labor employed than on family labor. Further, the increase in farm employment was greater in Thanjavur District, where farm labor was abundant and cheap and rice was the major farm product, than in Ferozepur District where farm labor was more expensive and wheat was a major crop. In Ferozepur, large farms which owned tractors tended to employ more hired labor per hectare than farms of comparable size without tractors, partially because of an increased intensity of land use.

Since efforts to increase farm production have a significant impact on farm employment opportunities, such efforts should be emphasized in less rapidly developing areas. Measures which increase the aggregate demand for farm products may be the key contributor to the growth of farm employment opportunities.

Keywords: India, farm employment, agricultural development, technological change, labor, green revolution.

Conversion Factors

1 rupee = U.S. $0.138 (official)

1 hectare = 2.47 acres

Washington, D.C. 20250 January 1973

PREFACE

Many areas in Asia now are or soon will be experiencing the "green revolution." The regions covered in this study were among the first in Asia to do so. As similar phenomena will be repeated in other areas in Asia, the relationships explored in this study will afford useful insights for these other areas.

The data used in this analysis were obtained from farm management data collected in 1967 and 1968 by the Farm Management Research Centers in Punjab and Tamil Nadu, and made available for analysis in 1970. The assistance of Mr. R.N. Kaushik, Indian Council of Agricultural Research; Dr. A.S. Kahlon, Director, Farm Management Research Center, Punjab Agricultural University, Ludhiana; and Dr. V. Shanmugasundaram, Honorary Director, Farm Management Research Center, University of Madras, Madras, in obtaining these data is gratefully acknowledged.

The support of USAID/India and members of that mission was important in the conduct of the study. The author freely and frequently obtained valuable guidance from William E. Hendrix, Martin Billings, and Arjan Singh, all of USAID/India.

Melvin G. Blase, of the University of Missouri, and L. Jay Atkinson and David E. Kunkel of the Economic Research Service provided frequent and valuable advice throughout the conduct of this study. In particular, the last section, "Aggregate Farm Labor Absorption," and appendix B are as much David Kunkel's product as that of the author.

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SUMMARY

Adoption of modern technology by farmers in two districts in India has not been accompanied by a reduction in employment of hired farmworkers. The total amount of labor employed per farm in the two districts in 1967/68 increased with increases in expenditures for seed and fertilizer. It also increased as bullock labor, farm size, and (in one district) irrigation increased.

Ferozepur and Thanjavur in the States of Punjab and Tamil Nadu, respectively, were the districts studied. Ferozepur is a major wheat-producing district, and hired labor is scarce relative to most other regions in India. Thanjavur, a major rice-producing district, contains a relatively large supply of hired labor. These districts were chosen because regional differences in demographic composition and farm production were expected to be important in explaining interregional differences in farm employment, and because features similar to those found in these two districts also prevail in other regions in India.

Objectives of the study included identifying variables which significantly influence the amount of family and hired labor employed per farm, and determining whether differences exist within districts as well as between them in the effect of variations in farm input use on the amount of family and hired labor employed. The factors investigated as possibly having an influence on labor employed per farm were (1) farm size, (2) irrigation expenses, (3) investment in farm machinery, (4) bullock labor, (5) expenses for seed and fertilizer, (6) percentage of high-yield varieties used, (7) price of the dependent variable, and (8) the amount of human labor employed other than that included in the dependent variable.

The study found that increased use of purchased inputs generated an increase in the amount of labor employed per farm and under certain conditions mechanization does not reduce the amount of labor employed per farm. Thus, increased use of purchased inputs can be effective in increasing total agricultural output, while at the same time increasing employment opportunities in agriculture.

Most of the increase in farm employment resulting from more intensive cultivation (e.g., increased use of irrigation, seed and fertilizer, and bullock labor) accrued to hired labor. The amount of family labor employed per farm was not significantly related to variations in the quantity of production inputs used per farm. The latter relationship seems to be due to short-run inelasticities in the supply of family labor to the farm enterprise.

In Thanjavur, increases in inputs per farm appeared to effect greater increases in the amount of labor employed per farm than in Ferozepur.

The wage paid to hired labor was not a significant determinant of the amount of hired labor employed per farm, with two exceptions. In Ferozepur, where wages paid to casual (seasonal) labor were relatively high, increases in

the wage resulted in significant decreases in the amount of such labor employed per farm. In Thanjavur, however, the quantity of permanent labor employed per farm rose significantly with increases in the wages paid to permanent workers. This seems to be related to the Pannaiyal system (a semi-feudalistic labor market which is no longer an important market for hired labor) in Thanjavur.

Variations in the value of farm machinery were not significantly related to variations in the amount of family or hired labor employed per farm. However, a few large farms in Ferozepur District used tractors, and these farms tended to employ slightly more hired labor per farm and per hectare than farms of comparable size without tractors. Farms with tractors also tended to use more purchased inputs and obtain a greater volume of output than on large farms without tractors.

Punjab farms are rapidly adopting new implements such as reapers and threshers. Because the cost of harvest labor is high and increasing relative to other parts of India, these implements may reduce the rate of increase in harvest labor employment opportunities stimulated by increases in farm production. The high wage rates, however, are indicative of an active and healthy labor market relative to other parts of India. Consequently, the mechanization of harvest operations in Punjab may be of less concern than in areas with fewer job opportunities.

In the two districts examined, there was little difference in the proportion of farmers by size of farm who were using high-yield varieties and related practices. These data do not demonstrate that small farmers in other areas are adopting new farm practices. Nevertheless, it appears that, with educational assistance, credit, and supplies of purchased inputs, small farmers can and will adopt these practices.

In addition to increased employment opportunities within agriculture, agricultural development stimulates growth in industries which service agriculture and provide products to satisfy an increased demand for consumer goods. Given the magnitude of the employment problem in India, steps should be taken to maximize nonfarm employment opportunities in rural areas.

The rate of aggregate increase in farm employment opportunities depends heavily on the rate of increase in aggregate demand for farm products. Efforts to control population growth, increase exports, promote development in dryland farming areas, and increase rural nonfarm opportunities will all contribute significantly to improving the income opportunities for India's rural workers.

AGRICULTURAL DEVELOPMENT AND FARM EMPLOYMENT IN INDIA*

By William J. Staub, Agricultural Economist, Economic Research Service

CHAPTER 1. INTRODUCTION

Several decades of experience with the problems facing developing countries have demonstrated that unemployment is not a symptom of underdevelopment which necessarily disappears as gross national product increases (49). 1/ Many developing countries face a serious and growing unemployment problem.

The problem of unemployment and underemployment in developing countries stems in large measure from the population explosion of the 1950's and 1960's. As a consequence, through the 1970's and beyond, large absolute increases in the size of the labor force will occur in most developing countries. In India, for example, the population has grown at an average rate of 2.4 percent per year since 1962. By 1985, India is expected to contain 761 million persons (274 million more than in 1965) (15, pp. 1, 37).

With the majority of the population residing in and deriving their income from the farm sector, this is where much of the population growth is occurring. In countries such as India, the proportion of the population in agriculture is as high as 70 percent. Since the number of persons employed in industry is small, a large portion of the labor force will need to remain in farm or farm-related occupations (16, pp. 22-23).

Between 1920 and 1950, farm production in India decreased relative to population (28, p. 141). From 1950 to 1968, however, food output per capita increased by 0.4 percent compounded annually (67, p. 11). More rapid progress in increasing agricultural output should improve farm incomes and increase employment opportunities for the growing farm labor force.

In 1965/66, high-yield varieties of wheat and rice were introduced into Indian agriculture. In 1968/69, 28.5 percent (4.4 million hectares) of the wheat area, 9.9 percent (3.7 million hectares) of the rice area, and 6.5 percent (3.1 million hectares) of the coarse grains area were planted to high-yield varieties. 2/ Farmers using these varieties and complementary purchased inputs obtain yields significantly greater than those previously achieved with traditional varieties. Moreover, the associated increase in the use of purchased inputs appears related to an increase in the amount of labor employed per farm (78). High-yield variety technologies therefore appear to be output increasing and labor augmenting.

*Footnotes are at end of report, p. 75.

Focus of the Study

This study examines the influence of agricultural development on farm employment in India. More specifically, it examines factors determining the short-run demand for family and two types of hired farm labor--permanent and casual (seasonal).

India contains many regions with diverse economic and demographic characteristics. Any national policy to maximize rural employment opportunities must explicitly recognize these regional differences. Characteristics which determine the scope of individual employment opportunities within regions are (1) the type of agriculture prevalent in the region, (2) the supply of farm labor as determined by population density within the region, and (3) the level of agricultural development.

Using these criteria, three regions can be identified. Western and central India, which includes the States of Rajasthan, Maharashtra, and Madhya Pradesh, is characterized by a general scarcity of irrigation water and has experienced relatively low rates of agricultural and economic development. Southern and eastern India includes the States of Tamil Nadu, Andhra Pradesh, Orissa, West Bengal, Bihar, and eastern Uttar Pradesh. These States have relatively high population densities and are major producers of rice. Some areas in southern and eastern India have adopted high-yield rice varieties and have experienced high rates of agricultural development. Northwestern India includes Punjab, Haryana, Himachal Pradesh, and western Uttar Pradesh. These States are major wheat-producing regions and have relatively low population densities. High-yield wheat varieties have been adopted widely in this area and agriculture is relatively productive.

This analysis focuses on two districts, one of which is characteristic of northwestern India and the other of southern and eastern India. Ferozepur District in Punjab, a major wheat-producing region, and Thanjavur District in Tamil Nadu, a major rice-producing area, were the districts selected for examination. Lack of data prevented the inclusion of a district in western and central India in the analyses.

Objectives

The specific objectives of this study were to (1) identify the set of variables which significantly influence the amount of family and hired labor employed per farm in the two areas, and determine what differences and similarities exist within and between the two regions in the effect of variations in use of farm inputs on the farm level utilization of family and hired labor.

Inferences are drawn with respect to four important issues related to the farm employment problem. These issues are (1) the general effect of agricultural development on farm employment, (2) the distribution of employment benefits among family and hired labor, (3) farm mechanization and farm employment, and (4) aggregate farm labor absorption. Insofar as the Indian experience in these regions is typical of other developing areas, these analyses also provide insights into general factors influencing farm incomes and employment during periods of rapid change in farm production.

Dimensions of the Indian Farm Employment Problem

At the outset of the 1960's, as in the two previous decades, almost 70 percent of the Indian labor force was engaged in farm production (table 1.1). Of the 131 million farmworkers, 76 percent (99.6 million) were reported as farm cultivators and 24 percent (31.5 million) were hired laborers. But this does not include the many tenants and small cultivators who derive most of their income from wage employment. 3/ Reflecting this difference, another study reported that 38 percent of the total labor force were agricultural laborers. (52, p. 1057)

Regional Differences in the Supply of Farm Labor

The distribution of the Indian labor force varies widely by States (table 1.2). 4/ Andhra Pradesh, with 5.8 million farmworkers, contains 17 percent of the farm labor force, while Assam, with 207,000 farmworkers, contains only 0.6 percent (column 1, table 1.2).

Since the Indian States are not of equal size, a more useful description of farm labor supply is one which describes the availability of farm labor relative to the amount of land in each State (column 2, table 1.2). Andhra Pradesh, Bihar, Tamil Nadu, and Kerala have the greatest supply of farm labor relative to land. Rajasthan, Punjab-Haryana, and Assam have the smallest. However, since Rajasthan, an arid State, has a land-extensive agriculture while

Table 1.1--Sectorial distribution of the Indian labor force, 1941, 1951, and 1961

Sector	1941	1951	1961	1941	1951	1961
	Million			Percent		
Agriculture	86.1	97.3	131.1	70.0	70.0	69.5
Farmer-cultivator ...	--	69.8	99.6	--	50.3	52.8
Farm laborer ..	--	27.5	31.5	--	19.7	16.7
Nonagriculture ..	36.9	42.2	57.5	30.0	30.0	30.5
Total	123.0	139.5	188.6	100.0	100.0	100.0

Source: (33, p. 397)

Andhra Pradesh has a very land-intensive cropping system, this measure is also somewhat deceiving.

A measure of the supply of farm labor which reflects interstate differences in agricultural production technologies is the number of days per year that farmworkers are unemployed (column 3, table 1.2). Kerala and Tamil Nadu have the greatest supply of farm labor by this measure, while Assam and Punjab have the smallest. These comparisons show that the severity of the farm employment problem varies greatly between States.

Regional Differences in the Supply of Hired Labor Relative to Family Labor

Both among and within regions, there is considerable variation in the number of farm operators relative to farm laborers. In Punjab, for example, hired farm laborers comprise about 12 percent of the farm labor force. In Tamil Nadu, on the other hand, 30 percent of the farm labor force are hired laborers (column 4, table 1.2). Further insight into interregional variations in the composition of the farm labor force can be obtained by examining several studies based on farm record data.

A study of farms in three villages in Bihar shows that, on average, family labor provided 80 percent of the total farm labor input, casual labor 15 percent, and permanent labor about 5 percent (78, pp. 84-90). According to another study, farmers in eastern Uttar Pradesh employed more hired labor than farmers in Bihar; family labor contributed 57 percent of the total quantity of farm labor used, and hired labor 43 percent (58, pp. 781-787). A detailed study of farm employment in nine villages in Maharashtra found considerable variation among villages in the proportion of farmworkers who were hired laborers--from less than 1 percent in one village to more than 34 percent in another (50, pp. 108-191).

Industrial Development and Nonfarm Employment

A large portion of the labor force will continue to obtain its livelihood from farm or farm-related occupations. Nevertheless, to rely exclusively on the labor-absorptive capacity of agriculture as a solution to India's unemployment problems is unrealistic. On the contrary, history shows that, as economic development proceeds, an ever-increasing portion of the labor force becomes engaged in nonfarm occupations. This observation partially explains the heavy emphasis on industrialization as a development strategy during the 1950's.

The industrial sector in countries like India, however, is not yet developed to a point where increased demand for labor in heavy industry and manufacturing is a major reason for population transfers from rural to urban areas (64, p. 227). While relative shifts in population from rural to urban centers have been and are now occurring, several decades will pass before the absolute size of the rural sector can be expected to decline (15, p. 3). Historically,

Table 1.2--The supply of hired farm labor, and hired labor as a percent of total farm labor by States, India, 1965

State	Number of hired farm workers 1/ (1)	Labor-land ratio (2)	Surplus labor days available per worker (3)	Hired labor as a percent of total farm labor (4)
	Thousand	Workers/acre	Days/worker	Percent
Andhra Pradesh...	5,890	0.487	67.3	41.6
Assam 2/.........	207	.075	16.5	5.3
Bihar............	4,877	.453	86.1	29.8
Gujarat..........	1,382	.137	3/ 51.9	21.6
Kerala...........	1,079	.423	121.3	45.3
Madhya Pradesh...	3,107	.175	46.4	20.9
Tamil Nadu.......	3,122	.442	99.1	30.4
Maharashtra......	4,978	.262	3/ 51.9	34.0
Mysore...........	1,944	.187	54.1	23.2
Orissa...........	1,438	.193	52.3	23.0
Punjab, Haryana..	600	.064	4/ 38.5	11.9
Rajasthan........	435	.029	59.2	5.2
Uttar Pradesh....	3,599	.163	49.1	15.0
West Bengal......	1,956	.306	73.7	28.4
Total.........	34,614	.227	66.6	24.0

1/ Estimated for 1964/65, assuming a 2.5 percent compound rate of growth per year.
2/ Figure is for Assam, Manipur, and Tripura.
3/ Figure is for the former state of Bombay.
4/ Figure includes Punjab, Haryana, Himachal Pradesh, and Delhi.

Source: Columns 1 and 2 are taken from (68, p. 5). Column 3 is adopted from (32). Column 4 is derived from (34, p. 15).

absolute declines in the size of the rural population have occurred rather late in the development process (12, pp. 1-11; 53, pp. 889-899). These demographic and employment shifts occur largely in response to the "pull" of economic opportunities in a developed and growing industrial sector.

Many developing countries, India included, are experiencing premature population transfers from rural to metropolitan areas. These population transfers stem from a scarcity of economic opportunities in the rural sector rather than from rapid increases in demand for labor in the industrial sector (40, p. 48; 80). In fact, given the need to develop basic heavy industries, development in the industrial sector has tended to be capital intensive rather than labor intensive. 5/

Moreover, advancing scientific knowledge and high labor costs in industrialized countries have led to the development of capital-intensive production techniques. Hence, in developing countries today, farm managers frequently have access to implements that substitute for labor even when wages are quite low.

Further, in some cases, labor has organized to artificially restrict the supply of labor. The artificially high wage rates relative to the price of capital encourage entrepreneurs to adopt capital-intensive production techniques (13, p. 7).

For all of these reasons, the industrial sector over the next decade or so is not apt to offer a marked increase in employment opportunities relative to the rural sector. 6/

Employment Intensity in Indian Agriculture

Because of India's large labor force, high man/land ratio, and low productivity per agricultural worker, Indian agriculture is frequently described as labor intensive. 7/ According to the law of variable proportions, this implies that the amount of labor employed in agriculture may be increased (without a corresponding decrease in labor productivity) by increasing the amount of capital and land relative to labor. In countries with high rates of rural population growth, this requires (1) population transfers to other sectors, and/or (2) increased use of purchased capital and land which exceeds the growth in the rural labor force. Without an adequate number of nonagricultural jobs, the former merely moves the problem from the farm to the urban sector. The latter, however, can result in real growth.

When compared with several other Asian countries, Indian agriculture is not labor intensive. Instead, relative to these other Asian countries it is labor and capital extensive and land intensive (table 1.3).

The productivity of Indian farm labor is low because Indian farms are, in general, not highly productive. The average product of farm labor, measured in

Table 1.3--Population density, farm input use, and agricultural productivity, 11 Asian countries, 1968

Country	Inhabitants per ha. of cultivated land	Farm output: Grain produced per ha.	Farm output: Grain produced per worker	Farm inputs: Area cultivated as percent of total land	Farm inputs: Workers per ha. of cultivated land	Farm inputs: N,P,K per ha. of cultivated land	Farm inputs: N,P,K per worker
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	No.	Kgs.	Kgs.	Pct.	No.	Kgs.	Kgs.
Japan...........	17.8	5,231	1,905	15.3	2.1	404.6	196.4
Taiwan..........	15.0	4,080	1,788	25.4	2.0	303.0	153.8
Cambodia........	2.3	1,397	1,533	16.8	.7	2.0	2.7
Korea...........	13.2	2,772	1,385	23.5	2.1	202.7	94.3
Laos............	3.5	953	1,176	3.3	1.0	25.0	24.6
Thailand........	2.9	1,644	966	22.3	1.1	9.2	8.4
Pakistan........	4.4	1,438	979	29.8	1.0	13.9	13.8
Philippines.....	4.3	1,070	974	28.7	.7	17.4	24.5
Indonesia.......	9.0	1,631	732	6.6	2.0	16.4	8.5
Vietnam.........	6.1	1,815	713	16.3	2.2	40.5	18.7
India...........	5.0	1,037	706	50.0	.9	10.3	11.6

Source: Adapted from data in (14).

kilograms of grain produced per agricultural worker, is less in India than in other Asian countries (column 3). Of equal importance, however, is the fact that the average product of land in India is less than that obtained in all but one other country (column 2).

Low productivity per unit of land and labor in India relative to other Asian countries is related to a low level of labor and capital use per unit of land. The amount of capital, measured in kilograms of fertilizer (columns 6 and 7), per hectare and per worker, is lower than in most of the other countries shown in the table. Further, the number of workers per hectare of cultivated land in India is less than that in all but two of the other countries (column 5).

An examination of data through the first two-thirds of the 20th century further demonstrates the land-intensive development of Indian agriculture. Over the last 50 years, the proportion of land area cultivated increased markedly. From 36 percent in 1919/20, the proportion of land area cultivated rose to 43 percent in 1936/38 and 50 percent in 1967/68 (60, p. 95; 81, p. 50). 8/

Simultaneously, the use of fertilizer and irrigation also increased. Irrigation facilities, however, were constructed primarily to prevent a complete crop failure due to drought and to bring new land into cultivation rather than to grow crops in the dry season (9, p. F-113). Consumption of inorganic fertilizers increased from 0.2 to 1.1 kilograms per hectare between 1938 and 1950. Relative to the amount of land cultivated, however, inorganic fertilizers were not widely used by Indian farmers (81, p. 50; 15, part 1). Only since 1950 has fertilizer become commonly used on Indian farms; 10.2 kilograms in 1967/68 (15, vols. 4 and 18).

The effect on crop output of the expansion in land area cultivated relative to fertilizer and other inputs is reflected in two ways. Output per hectare of wheat and rice declined by 8 and 12 percent respectively between 1936/37 and 1948/49. 9/ Further, between 1948 and 1962, 59 percent of the annual increment in food grain production was due to increases in area cultivated (27, p. 19; 28, p. 151).

The preceding discussion, while not conclusive, provides several insights. Low output per worker in Indian agriculture is not explained primarily by overutilization of labor relative to land. Rather, low output per worker appears to be related to low output per unit of land cultivated. In turn, low output per unit of land seems to be explained by extensive, rather than intensive, use of labor and capital in agriculture relative to land. More intensive use of capital in the form of fertilizer and irrigation should increase the production opportunities for labor in Indian agriculture. 10/

The Influence of Social Institutions on Farm Employment

While the rural employment problem in India has been compounded by rapid population growth, much of the rural employment problem centers around a large pool of unemployed landless or semilandless laborers. 11/ In addition to factors related to population growth, the size of this group has been determined by two features unique to India: (1) the British land reform scheme and (2) disintegration of the village as the basic unit of rural activity.

The British Land Reform

In pre-British India, land was essentially community property. For several reasons, one of which was to facilitate revenue collection, the British in the mid-1800's sought to consolidate the control of land (59, pp. 32-68; 81, p. 8). Through a series of edicts, landownership was transferred from joint village control to a relatively few large landlords or revenue collection agents. The pattern varied from region to region but in general the rights of land use shifted from the collectivism of the village to individuals (85; 20, pp. 10-40).

These changes in land control tended to concentrate the control of land into the hands of a relatively few people. Many large landowners were created outright. In other cases, many farmers who retained or obtained tenure rights to land quickly lost them because they could not cope with the system of moneylending which simultaneously emerged.

Disintegration of Village Institutions

Over time, the Indian village has been assimilated into the larger market economy of the region and thereby has lost much of its autonomous or self-sufficient character (73, p. 176). New goods introduced into the village economy through peddlers and merchants reduced the demand for goods produced by village artisans. Thus displaced, increasing numbers of village artisans have become agricultural laborers. Likewise, many functions formerly the responsibility of servant castes are now performed by other persons and are less identified with caste. Many of these persons have also joined the ranks of the hired farm labor force. The existence of a relatively large group of landless or semilandless laborers is due to many factors, of which population growth is only one. Any national policy to maximize rural employment will have to specifically address the many problems faced by this group.

Agriculture's Labor Absorption Capacity

Clearly, the agricultural population in India is going to increase during the next two decades at least. Hence, the basic question addressed by this study is whether and under what conditions farm labor employment can increase without a simultaneous decrease in labor productivity. Initial insights can be obtained by observing what happened in Japan--a country which, with fewer land resources per capita than India, has achieved development in the farm sector.

Hayami and Ruttan have explained the agricultural development of Japan as having followed a pattern which economized on the use of the scarce factor (land) while intensively using labor and biological capital.

> In Japan, the supply of land was inelastic and the price of land rose relative to wages. It was not, therefore, profitable to substitute land and power for labor. Instead, the opportunity arising from the declining price of fertilizer relative to the price of land was exploited through bio-chemical innovations (23, p. 1125; 8).

The labor- and capital-intensive agriculture which occurred actually involved a substitution of biological capital for land and made possible simultaneous increases in labor inputs per hectare, output per worker, and output per hectare. These are the very changes being sought in Indian agriculture.

Capital- and Labor-Intensive Agriculture in India

As in Japan, massive efforts have been made to develop biological capital in India for application by Indian farmers. Rapid yield increases in wheat and rice in some regions, due to the introduction of high-yielding varieties, testify to this. The net effect of the new production technologies has been to increase both output and the use of inputs. Farmers not only obtain greater output per hectare, but they use greater amounts of capital as well.

These capital inputs take the form of irrigation water and related equipment, fertilizer, seed, and pesticides. Energy is required to apply them to land. The increased use of farm capital per land unit implies an increase in the demand for farm energy. This energy may be supplied by humans, animals, or machines. In India, human energy furnishes much of the increased energy required.

The effect of technological progress on the intensity of capital and energy use on Indian farms is illustrated in table 1.4. Farms producing high-yield rice (HYR) incurred cash input costs 2.4 times the costs incurred on farms producing local rice varieties. Fertilizer expenses for HYR producers were about three times as great as those incurred by producers of local varieties. Expenditures per hectare for irrigation were twice as great for HYR as for local varieties--28 and 14 rupees per hectare, respectively. Cash expenditures for farm labor also were twice as large on farms producing HYR as on farms growing local varieties--367 and 191 rupees per hectare, respectively. Expenditures for farm labor as a percentage of total cash expenditures, however, were smaller on farms producing HYR--46 percent, versus 57 percent on farms growing local varieties.

Per hectare expenditures for inputs on wheat-producing farms are notably smaller than on farms producing paddy. Wheat requires considerably less labor per hectare than rice. Nevertheless, per hectare expenditures for all farm inputs on farms producing high-yield wheat (HYW) were 7.1 times those on farms growing local varieties. Farmers growing HYW spent almost five times as much for labor as farmers producing local wheat varieties. Labor costs as a percentage of total expenditures per hectare, however, were smaller for HYW than for local wheat varieties.

Hence, in the production of both wheat and rice, substantial increases in the amount of labor used are possible. Moreover, in spite of rather large increases in expenditures for labor, the amount spent for labor as a percentage of total expenditures per hectare decreases. This implies that more intensive use of biological capital makes possible increased use of farm labor without increasing the amount spent on labor as a percentage of total inputs. This is a particularly important feature in determining the labor-absorptive capacity of Indian agriculture.

Table 1.4--Cash costs per hectare for specified inputs: Amount and percentage of total, high-yield and local varieties of rice and wheat, selected areas in India, 1967/68

Crop and input	Cash costs: High-yield varieties	Cash costs: Local varieties	Percentage of total: High-yield varieties	Percentage of total: Local varieties
	Rupees per hectare		Percent	
Rice: 1/				
Seed	30.1	11.1	3.8	3.3
Fertilizer	311.8	101.3	39.0	30.2
Plant protection	21.0	3.0	2.6	.8
Labor	367.4	190.5	46.0	56.6
Irrigation	27.9	13.8	3.5	4.1
Other	40.5	16.8	5.1	5.0
Total	798.7	336.5	100.0	100.0
Wheat: 2/				
Seed	69.9	4.7	11.6	5.6
Fertilizer	229.3	21.7	37.8	25.5
Plant protection	3.4	.2	.7	.3
Labor	191.5	41.0	31.6	48.3
Irrigation	58.6	12.3	9.7	14.5
Other	52.6	4.9	8.6	5.8
Total	605.3	84.8	100.0	100.0

1/ Average for a cross section of farmers in seven States: Uttar Pradesh, Punjab, Tamil Nadu, Andhra Pradesh, Madhya Pradesh, Assam, and West Bengal.

2/ Average for a cross section of farmers in five States: Bihar, Haryana, Punjab, Rajasthan, and Uttar Pradesh.

Sources: (35, pp. 251-252; 36, pp. 97-98).

CHAPTER 2. FACTORS INFLUENCING FARM EMPLOYMENT

The Conceptual Model

This analysis is based on the assumption that the quantity employed and price paid to farm labor are determined by the intersection of the supply and demand relations for farm labor.

Under conditions of pure competition, individual farmers behave as price takers. Variations in product and factor prices are the consequence of changes in industrywide supply and demand relationships. While endogenous to the industry, changes in factor and product prices are viewed by an individual farmer as production constraints which he must adjust to, but can do little to change. Consequently, the price a farmer receives for his product and the prices he pays for inputs are determined by forces beyond his control.

Following from the above, the product demand curve and supply of purchased inputs to individual farmers are infinitely elastic with respect to price. In the course of a single production period, the demand for a factor of production by an individual firm is not defined as a function of the demand for the final product. Rather, the demand for an input is defined as a function of the production function, with relative factor and product prices taken as given. 12/

Since the purpose of this study was to obtain insights into factors influencing the amount of labor employed per farm, employment elasticities were estimated for a simultaneously determined structural system. This system contains factors generally viewed as being related to the demand for rather than the supply of farm labor.

Specification Problems

Price and quantity equilibrium positions are jointly determined by the intersection of the supply and demand relations for the commodity in question. Estimation of parameters in a derived demand relation, therefore, requires that the supply relation be (1) specified, or (2) assumed to be infinitely elastic.

Analyses using aggregate data must specify the supply and demand relations. 13/ The assumption of an infinitely elastic input supply curve is unrealistic where aggregate (industrywide or time series) analyses are used. Individual farmers, however, generally face an infinitely elastic product demand curve as well as a perfectly elastic supply curve for purchased inputs. Hence, by assuming that the supply of hired labor is infinitely elastic with respect to price, the parameters of a derived demand relation for hired labor can be estimated without also specifying the supply relation.

The supply of family labor, however, is determined within the family unit. The supply of family labor depends on factors such as (1) size of the family, (2) the opportunity cost of employment on the family farm, and (3) the returns from employment on the family farm.

In light of the unique characteristics of family labor, the following assumptions are required: First, the opportunity cost of family labor, while probably greater than zero, is assumed to be less than earnings obtainable on the family farm. Second, the supply of family labor on a given farm is considered to be infinitely elastic with respect to price, up to the limits imposed by the number of family members. Family size can be increased over the long run. Over the short run, however, and hence for this analysis, the supply of family labor is assumed to be limited by the current size of the farm family.

An Algebraic Statement of the Model

The models examined in this study are described algebraically as:

$$L_f = \phi\ (X_{1f}, \ldots X_{nf}, P_{Lf}, L_{pf}, L_{cf})$$

$$L_p = \phi\ (X_{1p}, \ldots X_{np}, P_{Lp}, L_{fp}, L_{cp})$$

$$L_c = \phi\ (X_{1c}, \ldots X_{nc}, P_{Lc}, L_{fc}, L_{pc})$$

where L_f, L_p, and L_c respectively identify the quantity of family, permanent, and casual labor employed per farm; $X_1, \ldots X_n$ identify a set of production function variables; and P_{Lf}, P_{Lp}, and P_{Lc} identify the price paid to each kind of farm labor.

The estimated regression coefficient identifies the functional relationship between the respective independent variables and the respective dependent variables. When such a system is estimated by least-squares regression with all variables specified in logarithms, the regression coefficients can be interpreted directly as employment elasticities. When alternative functional forms (e.g., arithmetically linear) are used, the regression coefficients may be algebraically transformed to obtain estimates of the employment elasticities. 14/ These employment elasticities can be used to draw inferences with respect to the influence of selected variables on the amount of various kinds of labor employed per farm.

Variables Influencing the Demand for Farm Labor

The following three types of variables are hypothesized as being significant determinants of the quantity of family and hired labor employed per farm: (1) Production function variables, (2) the price of labor, and (3) substitution variables. The production function variables influence the demand for labor through their effect on the marginal value product of labor. The price of labor, given an infinitely elastic supply curve facing the farmer, specifies the equilibrium point on the input demand curve and determines the quantity of labor used. The substitution variables identify the net substitution relationship between family and hired labor.

Production Function Variables

The production function variables considered in this study are (1) farm size, (2) irrigation expenses, (3) value of farm machinery, (4) tractor ownership, (5) the amount of bullock labor employed, (6) expenditures for seed and fertilizer, and (7) percentage of wheat or rice area sown to high-yield varieties.

Farm Size.--Farm size, measured in land area cultivated per farm, defines the base unit on which capital and labor are applied. Consequently, a ceteris paribus increase in farm size causes the marginal value product curve for labor to shift to the right. Farm size, therefore, is expected to be positively related to the amount of family and hired labor employed per farm.

The employment elasticity for family labor with respect to farm size may be smaller in positive magnitude than the employment elasticity for hired labor. The supply of family labor--the upper bound of which is determined by the number of family members per farm--need not increase in proportion to increases in farm size. If family size does not vary markedly as a function of farm size, the short-run employment elasticities for family labor with respect to farm size may be smaller than would otherwise be the case.

Irrigation.--Irrigation influences the demand for farm energy in three ways. First, water is in itself a production input. When rainfall is insufficient or arrives at inopportune times, measured application of irrigation water increases the output obtained from other resources with which it is combined, thereby encouraging increases in the use of these resources. Second, irrigation reduces or eliminates the need for fallowing land. 15/ Third, irrigation itself requires some labor input. The first two factors tend to shift the marginal value product of labor to the right while the third describes the technical product factor combination between labor and irrigation water. Consequently, variations in irrigation expenses are expected to positively influence the amount of family and hired labor employed per farm. 16/

Farm Implements.--Farm implements are defined in terms of the current value of major and minor implements. These include hand tools, field implements drawn by some form of draft power, and tractors. 23/ Because of the effect of implements on the capital-absorptive capacity of land within and among seasons, a positive relation between farm implements and family and hired labor is expected.

Farm tractors refer to tractors in the 20- to 40-horsepower range, not to small garden-size power units. Tractors, a special case of the implements described above, substitute directly for bullock labor. Because the time required per operation is reduced, tractors may also substitute for some types of human labor. There is a large difference in the amount of labor required per operation where tractors as compared with bullock power are used. 18/ This substitution effect may be offset by an increase in employment due to greater cropping intensity on farms using large tractors.

There are two theories regarding the net effect of the introduction of farm tractors on farm employment. Some analysts fear that the increase in labor required from an increase in production intensity may not be sufficient to offset the direct substitution effect (41). The United Nations Food and Agricultural Organization (FAO), a body which is highly sensitive to farm employment problems, takes a different position. FAO asserts that the increase in intensity of production on farms where tractors are used may in some circumstances more than offset the substitution effect (16, pp. 225-228). These divergent views differ primarily with respect to the amount of additional employment made possible by increased cropping intensity on tractorized relative to nontractorized farms. Consequently, the net effect of tractors on farm employment is not a priori obvious.

While the net employment effect of tractors is not initially apparent, hired labor seems likely to bear the greatest brunt of any employment effect caused by tractors. As demonstrated later, tractors are used primarily on large farms. Hired labor most frequently performs those tasks which can be performed jointly with either tractors or bullock labor. Family labor on large farms often is engaged in production activities somewhat different from the employees' tasks. Consequently, hired labor is apt to be more noticeably affected than family labor by adoption of tractors.

Bullock Labor.--For tasks such as hauling, plowing, and threshing, bullock teams have traditionally furnished the draft power required. A bullock team permits a farm operator to increase production to a level which is impossible without such sources of power. In addition, the technical factor combination of one man per bullock team makes these two inputs complementary with each other. Since bullock labor permits farm operators to engage in activities not possible on farms where bullock power (or a substitute) is not used, the amount of bullock labor used is expected to be positively related to the quantity of family and hired labor used per farm.

Hired labor may be more closely related than family labor to variations in bullock labor. Farm operators, while not necessarily freed from operations involving bullock labor, frequently delegate these repetitive tasks to hired labor.

Seed and Fertilizer.--Expenditures for seed and fertilizer (in addition to irrigation) indicate the degree to which a farm operator is following modern farm production practices (table 1.4). Further, the amount spent for these inputs directly measures the intensity with which a farmer is using a very important form of biological capital.

Greater use of improved seeds and fertilizer increases the demand for labor (its marginal value product) by expanding the amount of capital used per farm relative to labor. Moreover, the absolute increase in capital employed per farm implies an absolute increase in farm energy per farm. Consequently, the amount of seed and fertilizer used per farm is expected to be positively related to the quantity of family and hired labor employed per farm.

High-Yield Varieties.--Farmers adopt new inputs and production techniques slowly as they become familiar with these practices. Adoption of high-yield varieties of rice and/or wheat is frequently associated with the use of modern production practices and more intensive use of fertilizer and other inputs. The level of adoption of high-yield varieties may be taken as an indicator of farmers' familiarity with or use of the associated bundle of practices. The level of adoption of high-yield varieties, therefore, is expected to be positively related to the quantity of family and hired labor employed per farm. 19/

Price of Labor

The quantity demanded of a factor of production varies inversely with the price paid for that input. Consequently, a negative relationship is expected between the quantity of hired labor employed per farm and the wage paid to hired farm labor. The supply of family labor, however, is determined endogenously within the firm. The price paid to family labor, therefore, may be a determinant of both the supply and the demand for family labor.

Hired Labor.--This study assumes that farmers face an infinitely elastic supply curve for purchased inputs. Yet, the wage rates paid to permanent and casual labor are key components in this analysis. Variations in input prices, however, are inconsistent with an infinitely elastic input supply curve.

Most permanent and casual labor employed by a given farmer is recruited from the local village. Wage rates for hired labor may vary among villages due to local variations in the supply of and demand for hired labor. However, given that each village represents a more or less self-contained hired labor market, individual farmers within villages generally face an infinitely elastic supply of hired labor. This relationship, as demonstrated in the following chapter, explains the existence of variations in wages for hired farm labor in the cross section data without departing from the simplifying assumption with respect to the nature of the supply of hired farm labor available to individual farmers.

Family Labor.--The amount of family labor employed per farm is hypothesized as being functionally related to the monetary return to family members from employment on their own farm. However, given the framework of analysis and the data available for examination, economically interpretable parameters could not be estimated for family labor with respect to the price of family labor. Consequently, this variable is not included in the regression analysis which follows. 20/

Substitution Variables

Hired labor may supplement and/or substitute for family labor. The combination of family and hired labor employed per farm is determined on the basis of the opportunity cost of family labor, the demand for total human energy, and the price of hired labor.

The observed relationship between family and hired labor is the result of the joint substitution and supplementary relation between the two kinds of labor. A negative substitution elasticity between the two kinds of labor is evidence that the substitution effect is sufficient to countervail any supplementary relationship between them. Conversely, a positive substitution elasticity indicates that the supplementary relation overshadows any substitution effect. There is however, no a priori basis for choosing among these two alternatives.

CHAPTER 3. ECONOMIC AND DEMOGRAPHIC CHARACTERISTICS IN FEROZEPUR AND THANJAVUR

Located at opposite ends of the country, Ferozepur and Thanjavur Districts exhibit many contrasts in socioeconomic characteristics. Ferozepur, on the Indo-Pakistan border, is the largest district in Punjab. Punjab is a highly industrialized State, and only 56 percent of those employed were engaged in farming. Agriculture is more important in Ferozepur and 66 percent of those employed were engaged in farm production. 21/

By Indian standards, Ferozepur, with a population density of 160 persons per square kilometer, is not densely populated. Population density in Punjab as a whole in 1961 was 220, compared with 148 for the entire country (61, p. 10).

In contrast with other parts of the country, hired agricultural labor comprises a small portion of those engaged in farming activities. As of 1960/61, 88 percent of the farm work force in Punjab were cultivators while 12 percent were classed as hired laborers. In Ferozepur, 20 percent were farm laborers.

Wheat is Ferozepur's major agricultural crop, and high-yield varieties have been widely adopted. Farms in the district are large and most are owner operated. A large portion of the land is irrigated.

Thanjavur District, in Tamil Nadu, is in extreme southeast India and borders the Bay of Bengal. About 60 percent of the working population in Tamil Nadu are engaged directly in agricultural production. In Thanjavur, however, 70 percent of the working population were engaged in farming. 22/

The district has a high population density--335 persons per square kilometer in Thanjavur, compared with 259 for the State (79, p. 15).

A high proportion of landless agricultural workers is a characteristic of the State which is found accentuated in Thanjavur. In 1960/61, about 70 percent of those employed in agriculture in Tamil Nadu were defined as cultivators while 30 percent were agricultural laborers. In Thanjavur, the corresponding proportions were 53 and 47 percent, respectively (79).

Farms in Thanjavur are small and frequently consist of several fragmented plots. Agriculture in the region is a virtual monoculture in rice. Almost all farms obtain irrigation from the Cauvary River public irrigation system.

The Sample

Data used in the following regression analyses derive from a stratified random sample of 150 farms in Ferozepur and Thanjavur. 23/ Fifteen villages in each district were selected at random. Within each village, a census of cultivators was compiled and arrayed in descending order of size of operational holding. This list of farms was divided into five groups, each containing one-fifth of the area cultivated. From each group, two farmers were selected at random. In this way, observations were obtained from 10 farmers in 15 villages in each district. The stratified random sample insured that observations were obtained from a broad spectrum of farm sizes. 24/

Data obtained from those interviewed are cost account data and deal with every major aspect of the farm enterprise for the 1967/68 production year. These data were originally gathered by the Farm Management Research Centers in Punjab and Tamil Nadu under the auspices of the Indian Council for Agricultural Research for use in the Studies in the Economics of Farm Management for each district.

Type of Farming

Ferozepur

Punjab is the wheat belt of India. In 1968/69, some 57 percent of the gross cropped area was planted to wheat. Between 1965/66 and 1968/69, wheat area increased 30 percent and average wheat yields increased 75 percent. This combination of factors resulted in a 134-percent increase in wheat production (table 3.1).

Table 3.1--Area and production of major agricultural products, Punjab, 1960/61, 1965/66, and 1968/69

Crop year	Rice	Wheat	Other cereals 1/	Pulses	Total food grains	Other crops 2/	Total
	1,000 hectares						
1960/61 ...	228	1,394	530	948	3,100	770	3,870
1965/66 ...	293	1,548	513	645	3,099	874	3,973
1968/69 ...	345	2,063	778	411	3,597	872	4,469
	1,000 metric tons						
1960/61 ...	236	1,725	481	756	3,198	1,396	4,594
1965/66 ...	293	1,916	792	390	3,391	1,764	5,155
1968/69 ...	470	4,491	988	263	6,212	1,721	7,933

1/ Jowar, bajra, maize, barley, other cereals.

2/ Sugarcane, potatoes, oilseeds, cotton, chillies, tobacco.

Source: (61, pp. 72-75).

Table 3.2--High-yield wheat area as percentage of area sown to all wheat, Punjab and Ferozepur, 1967/68 and 1968/69

Region	1967/68			1968/69		
	All wheat	High-yield wheat		All wheat	High-yield wheat	
		Area	Percent of all wheat		Area	Percent of all wheat
	Hectares	Hectares	Percent	Hectares	Hectares	Percent
Punjab........	1,790	621	34.7	2,063	1,199	58.0
Ferozepur....	1/ 347	125	36.6	395	205	52.0

1/ Area sown to wheat in Ferozepur in 1967/68 was calculated by assuming that the proportional increase in wheat area between 1967/68 and 1968/69 was the same in Ferozepur as in Punjab.

Source: (61, pp. 72, 73, 84).

Key factors in the expansion of wheat have been (1) a 16-percent expansion in area irrigated, which permitted an increase in multiple cropping and a substitution of wheat for other Rabi (dry season) food grains, and (2) the rapid adoption of high-yield wheat varieties.

In Ferozepur, 37 percent of the land area sown to wheat in 1967/68 was a high-yield variety (table 3.2). 25/ By 1968/69, over one-half of the land in wheat was sown to high-yield varieties. Of the 150 Ferozepur farms analyzed in this study, 71 percent were using high-yield varieties on some of their land in wheat and 7 percent were using only high-yield varieties, while 22 percent had not yet begun to use high-yield varieties. 26/ Consequently, a cross section of farmers in Ferozepur in 1967/68 contains observations from farms at varying levels of application of modern farm inputs.

Thanjavur

Thanjavur is an Intensive Agricultural Development Program (IADP) District. Selected for that program primarily because of an assured supply of irrigation water, farmers in this district have received large amounts of assistance in adopting modern production techniques and inputs. Thanjavur had 76 percent of its gross cropped area in rice in 1965/66 (table 3.3). An abundance of river-based irrigation plus two monsoons permit three cropping seasons. Typically, the Kuruvai season, which lasts from June to October, is the most important. This is also the season of peak labor requirements. For the Kuruvai crop, most farmers plant ADT-27, a high-yielding rice variety developed in India. This is a short-duration (105 days), high-yield rice which responds profitably to up to 72 kilograms of nitrogen per hectare. First introduced in 1965/66, this variety had by 1967/68 been widely adopted by farmers in the region.

Table 3.3--Area and production of major agricultural products in Thanjavur, 1963/64 and 1965/66

Crop year	Rice	Other cereals	Pulses	Total food grains	Other food crops	Non-food crops	Total
	1,000 hectares						
1963/64....	604	18	30	654	24	84	762
1965/66....	609	21	33	663	24	112	799
	1,000 metric tons						
1963/64....	894	21	7	922	1/	---	---
1965/66....	911	23	7	944	---	---	---

1/ Other food and nonfood crops are too heterogeneous with respect to value per kilogram to permit aggregation on the basis of weight.

Source: (47)

Of farms sampled in Thanjavur in 1967/68, 82 percent were growing ADT-27. Another high-yield variety, CO-25, which has a lower yield potential, is planted in the two less important crop seasons. In these seasons, called Samba and Thaladi, 85 and 83 percent of the farmers respectively were growing the recommended CO-25 variety.

Farm Size and Tenure

Ferozepur is a district of large farms in a State consisting of large farms. Mean farm size, measured in net area cultivated, for the farms sampled in Ferozepur was 12.6 hectares.

Few farmers in Punjab are strictly tenants. Of the Ferozepur farmers surveyed, 108 were complete owner-operators, 41 rented some land, and only one was a complete tenant.

Thanjavur is a district of small farms in a State consisting of small farms. Mean farm size for the farms surveyed was 2.8 hectares. Mean farm size in Tamil Nadu was 1.7 hectares.

Farm tenancy is of greater significance in Thanjavur than in Ferozepur. Of those farmers surveyed in Thanjavur, 19 percent were complete tenants and 47 percent rented some land. Farm fragmentation is a key constraint on farm efficiency. Farms in the sample had an average of 11 fragments per farm.

Employment on Alternative Sizes of Farms

The sample farms in Ferozepur were approximately four times as large as sample farms in Thanjavur. This is reflected by the fact that Ferozepur farms on average employed 80 percent more man-days of labor per farm than Thanjavur farms--930 and 525 man-days per farm, respectively.

The amount of family, permanent, and casual labor employed per farm increases as a function of farm size in both districts (table 3.4). The composition of the labor employed on farms, however, changes as farm size

Table 3.4--Employment of family, permanent, and casual labor per sample farm, by size class of farm, Ferozepur and Thanjavur, 1967/68

District and size class 1/	Mean size per class	Family (1)	Permanent (2)	Casual (3)	Total (4)	Family 2/ (5)	Permanent 3/ (6)	Casual 4/ (7)
	Ha.	Days				Percent		
Ferozepur:								
1.......	4.4	287.6	63.1	264.2	614.9	46.7	10.3	43.0
2.......	7.8	360.4	156.4	140.9	657.7	54.8	23.8	21.4
3.......	10.9	402.8	278.9	220.1	901.8	44.7	30.9	24.4
4.......	15.9	417.1	411.0	279.0	1,107.1	37.7	37.1	25.2
5.......	24.1	453.4	481.9	435.0	1,370.2	33.1	35.2	31.7
Thanjavur:								
1.......	.9	87.8	1.5	87.4	176.7	49.7	.8	49.4
2.......	1.6	110.9	14.0	166.9	291.8	38.1	4.8	57.1
3.......	2.2	127.6	27.9	288.7	444.2	28.8	6.3	64.9
4.......	3.2	139.1	92.4	464.7	696.2	19.9	13.3	66.8
5.......	6.2	156.0	197.0	662.7	1,015.7	15.3	19.3	65.2

1/ The size classes used here, while indicating a rank ordering of farms in terms of number of hectares cultivated, are not based on a predetermined absolute size of farm. Rather, farms in size group 1 consist of a proportionate sample of the population of the smallest farms which comprise 20 percent of the area cultivated in the sample area. With five size groups, observations are obtained from groups of progressively larger farmers representing all strata of farm sizes commonly found in the sample area.

2/ Column 1 divided by column 4.

3/ Column 2 divided by column 4.

4/ Column 3 divided by column 4.

increases. As expected, the amount of family labor employed per farm increases less than in proportion to the total increase in labor as farm size increases. Hired labor (permanent and casual labor), however, increases more than in proportion to the total increase in farm labor employed per farm (columns 5, 6, and 7, table 3.4). This tendency is attributable to several factors.

The supply of family labor--the upper bound of which is determined by the number of family members per farm--does not, on the average, increase in proportion to the increase in labor required per farm as farm size increases. 27/ Consequently, larger farms tend to hire a greater portion of the total labor used. Second, large farm operators spend a high portion of their time in managerial roles, and have less time to engage in work activities.

On smaller farms, the need for hired labor may be highly seasonal. Consequently, smaller farmers will hire primarily casual laborers. As farm size increases, hired labor services are required at nonseasonal peak periods also. On farms where supplemental labor is required throughout most of the year, farm operators hire permanent laborers. Nevertheless, on these larger farms casual labor is still required to satisfy seasonal work requirements.

In Ferozepur, the amount of labor employed per hectare tends to decrease as farm size increases (table 3.5). Since output per hectare did not substantially decrease as farm size increased, this implies that the larger Ferozepur farms may have been using other kinds of farm energy instead of human labor.

On Thanjavur farms, the proportional and absolute decrease in employment per hectare as farm size increases is smaller relative to that observed in Ferozepur farms (column 4, table 3.5). This seems related to the fact that, in Thanjavur, the absolute variation in farm size is less than in Ferozepur. Further, rice is more labor intensive than wheat.

Rice being the dominant crop in Thanjavur, large farmers in Thanjavur may be less able to substitute other forms of energy for hired labor than large farmers in Ferozepur.

Irrigation

All farms examined in each of the two districts had at least some irrigated land. Most farmers, particularly farmers in Thanjavur, obtained irrigation water from a public canal distribution system.

Ferozepur

Ferozepur receives only 13.6 inches of rainfall per year, and three-fourths of this falls between June 15 and September 15. Consequently, irrigation is essential for intensive production during the Rabi season.

Table 3.5--Employment of family, permanent, and casual labor per hectare and value of output per hectare, by size class of sample farms, Ferozepur and Thanjavur, 1967/68 1/

District and size class	Mean size per class	Family labor (1)	Permanent labor (2)	Casual labor (3)	Total labor (4)	Value of output (5)
	Ha.	Days per hectare				Rupees per ha.
Ferozepur:						
1.......	4.4	65.4	14.3	60.0	139.8	2,093.8
2.......	7.8	46.4	20.1	18.2	84.8	1,786.4
3.......	10.9	36.8	25.5	20.1	82.4	1,931.7
4.......	15.9	26.3	25.9	17.6	69.8	1,667.0
5.......	24.1	18.8	20.0	18.0	56.8	1,900.8
Thanjavur:						
1.......	.9	98.6	1.7	98.1	198.4	1,524.5
2.......	1.6	70.0	8.8	105.4	184.3	1,503.0
3.......	2.2	57.1	12.5	129.2	198.8	1,587.3
4.......	3.2	43.4	28.8	145.1	217.4	1,488.3
5.......	6.2	25.1	31.7	106.6	163.4	1,455.3

1/ Items in columns 1 through 4 were calculated from table 3.4.

Well endowed with irrigation facilities, about 76 percent of the net sown area in Ferozepur is irrigated (table 3.6). Most irrigation water comes from government-owned canals. Over 80 percent of the irrigated land received water in this manner. The remainder is irrigated by wells and tubewells.

Thanjavur

Irrigation water is a key factor of production in the district, not so much because of rainfall scarcity, but because of the water requirements of rice. Rice requires a constant level of stagnant water during a crucial period of its growth cycle.

About 84 percent of the net sown area in the district in 1965/66 was irrigated. Almost all of the irrigation water was supplied by government canals which divert water from the Cauvary River (table 3.7). Irrigation water is most readily available to persons at the head of the irrigation canals. Individual farmers further down the canals have no control over the amount or time at which water is made available to them. 28/

Table 3.6--Net area irrigated by specified sources, Punjab and Ferozepur, selected years, 1960/61 to 1968/69

District and year	Government canals	Private canals	Tanks	Wells and tubewells	Other	Total	Percent of net area sown
	1,000 hectares						Percent
Punjab:							
1960/61	1,174	7	---	824	14	2,019	54
1965/66	1,289	6	---	887	77	2,263	59
1967/68	1,288	5	---	989	7	2,289	57
1968/69	1,290	4	---	1,352	6	2,652	67
Ferozepur:							
1968/69	470	---	---	115	---	585	76

Source: (61, p. 125).

Table 3.7--Net area irrigated by specified sources Thanjavur, 1963/64 and 1965/66

Year	Source of irrigation				Total area irrigated	Percent of net area sown
	Canals	Tanks	Wells and tubewells	Other		
	1,000 hectares					Percent
1963/64	473	28	4	---	505	84
1965/66	466	30	7	---	503	84

Source: (47).

Moreover, since, to drain a field, a farmer must frequently release this water through a neighbor's field, individual farmers cannot drain their fields when they wish. Because of these institutional procedures by which public canal irrigation water is allocated to farmers, expenses for irrigation water cannot be considered a variable input; that is, the entrepreneur cannot freely vary it over the short run so that net profit is maximized. Irrigation water should be available as a variable input if the farmer is to take full advantage of modern production inputs and practices.

Canal irrigation has long been commonly used in Thanjavur, and water is allocated to farmers through a State-operated system in accord with procedures implemented many years past. For many reasons, one of which is the inability to regulate the amount of water a farmer receives, these allocation procedures do not necessarily coincide with irrigation water needs under modern farming systems.

Farmers served by the irrigation system pay a fee to the irrigation authority based on a fixed water rate multiplied by the amount of land served. The fee does not vary with the amount of irrigation water actually received. In the sample, only owners of farmland reported having expenditures for "irrigation and land revenue." All farmers, however, whether tenants or landlords, irrigated virtually all of the land cultivated. Tenants most likely pay for irrigation through higher land rent.

Since farmers pay for irrigation to the same government agency which collects property taxes, irrigation and property taxes were reported jointly. Property taxes, however, vary with the productivity of the land. Land productivity in turn varies directly with the location of land relative to the head of the canal (86, p. 24). Hence, data which precisely define variations in expenditures for canal irrigation were not available. In view of this difficulty, the variable "irrigation expenses" was deleted from the regression analysis in Thanjavur.

In Ferozepur, canal irrigation more closely approximates the concept of a variable cost. Farmers served by the irrigation system have the option to purchase or not to purchase canal irrigation water. But they cannot control the number of times or amount of water made available to them. Farmers are charged for the actual area irrigated and rates vary directly with the water requirements of the crop grown on the irrigated land. Farmers in Ferozepur are not faced with drainage problems as are Thanjavur farmers. Expenses for irrigation were reported as a unique expense by Ferozepur farmers. Hence, irrigation expenses on Ferozepur farms were included in the regression analysis.

Fertilizer

Compared with the all-India average of 10.7 kilograms of nitrogen, phosphorous, and potash (N,P,K) per hectare, farmers in Punjab and Tamil Nadu apply large quantities of fertilizer--29.1 and 19.5 kilograms of N,P,K per hectare respectively (31, p. 159).

Data on fertilizer use in Ferozepur are not available for recent years. On sample farms, however, farmers spent Rs. 150 per hectare for seed and fertilizer. Average expenditure for seed and fertilizer was Rs. 1,891 per farm. Only nine farmers used no inorganic fertilizers.

Fertilizer consumption in Thanjavur increased fivefold between 1960/61 and 1968/69. This is reflected in a fourfold increase in per hectare use of nitrogen and P_2O_5 (table 3.8). Farmers sampled in Thanjavur spent Rs. 646 per farm and Rs. 229 per hectare for seed and fertilizer.

Table 3.8--Use of nitrogen and P_2O_5 districtwide, total and per hectare, Thanjavur, selected years, 1960/61 to 1968/69

Year	Districtwide total	Per hectare
	Metric tons	Kilograms
1960/61	31,034	1.6
1964/65	87,461	4.2
1967/68	149,153	7.8
1968/69	162,731	8.4

Source: (38, p. 14).

Tractors and Other Implements

Bullock-drawn field preparation implements such as steel point plows are widely used in both districts. Until recently, tractors were not widely used in Indian agriculture. For example, in 1947 there were only 4,515 tractors in the entire country (14, p. 123). In Punjab, however, tractors are becoming popular on large farms. In Punjab alone, tractor population increased from less than 5,000 in 1960/61 to 10,636 in 1965/66, and to more than 20,800 in 1967/68 (61, p. 175; 66, p. 217). In 1965/66, one-third of the tractors in Punjab were in Ferozepur. One in six sample farms in Ferozepur had a tractor. While no farms under 12 hectares owned a tractor, 30 percent of those which exceeded 12 hectares did own a tractor.

For several reasons, tractors, while common in Ferozepur, are not widely used in Thanjavur. First, both farm and average field unit size are smaller in Thanjavur than Ferozepur. 29/ Second, the supply of hired labor relative to demand is much greater in Thanjavur than in Ferozepur. Farmers in Ferozepur, particularly at harvesttime because of high wage rates and delays in harvest operations, have stronger inducements than farmers in Thanjavur to buy tractors and other laborsaving implements.

The Market for Hired Labor

Rapid modernization in agriculture, the presence of large farms requiring large quantities of labor, a relatively low population per square kilometer, and a relatively small portion of the farm work force classed as farm laborers in Ferozepur have resulted in farm wages in that district far exceeding those prevailing in Thanjavur. While significant changes have occurred in Thanjavur agriculture, relatively smaller farm size, a more dense population, and a larger portion of the farm work force classed as hired laborers have prevented farm wages in Thanjavur from increasing to levels found in Ferozepur.

In Thanjavur, casual laborers on sample farms were paid Rs. 2.9 per day while permanent laborers received Rs. 2.3 per day. In Ferozepur, casual laborers received Rs. 5.0 per day and permanent laborers were paid Rs. 5.5 per day. Consequently, farm wage rates are less apt to be a significant determinant of the quantity of hired labor employed per farm in Thanjavur than in Ferozepur.

Variations in Wage Rates

In chapter 2 the assertion was made that variations in wage rates paid hired labor by individual farmers were explained by variations in the supply and demand equilibrium position for hired labor between villages. Individual farmers within villages, however, faced an infinitely elastic supply curve for hired labor. This apparent contradiction is explained by the fact that, with the exception of permanent labor in Thanjavur, much but not all of the variation in wages paid to hired labor was explained by variations in labor market conditions between villages. 30/ Wages paid casual laborers in Ferozepur were more volatile than wages paid casual or permanent labor in Thanjavur. Wages paid permanent laborers in Thanjavur varied least.

The Market for Permanent Labor in Thanjavur

Institutions for marketing farm labor are subject to unwritten codes and regional variations; meaningful generalizations are difficult to obtain. In Thanjavur, the market for permanent labor since 1952 has undergone significant structural changes. These changes are in large measure responsible for the small degree to which farmers in Thanjavur employ permanent laborers (table 3.4). On the average, sample farmers in Thanjavur employed 334 man-days of casual labor per farm and only 67 man-days of permanent labor. Moreover, all Thanjavur farmers employed some casual labor, but only 68 of 149 farms employed permanent laborers.

Traditionally, the market for hired labor in Thanjavur operated through the Pannaiyal system, whereby farm laborers were hired as a family unit under a socially binding oral contract. 31/ This contract could be terminated by the Pannaiyal only with the consent of the landlord. As wages, Pannaiyal laborers received food, clothing, shelter, a token cash wage, and the right to use a small portion of the farmer's land for their own cultivation. Seed, bullock labor, and farm manure were furnished. However, as sometimes occurs in relationships between individuals of unequal power, abuses became widespread.

The Tanjore Tenants and Pannaiyal Protection Act of 1952 was implemented to correct many of these abuses. The Act prescribes minimum wage rates, security of service, and other privileges to Pannaiyal laborers. Farmers have responded, however, by discontinuing their use of Pannaiyal laborers. While the same persons may still be hired on a given farm, they are often hired as casual laborers. Hence, this institution, very popular in the 1940's, is now employed on only a few large farms. The legislation, therefore, appears to have contributed to a shift in the farm labor market in Thanjavur from permanent to casual laborers.

Nevertheless, many laborers still work under the rules of the Pannaiyal system and are subject to similar, albeit modified, rules as described above. Insofar as this labor market operates on the basis of tradition, in contrast with the market for casual labor in Thanjavur and both kinds of hired labor in Ferozepur, the relation describing the use of permanent labor in Thanjavur may contain parameters inconsistent with economic logic.

CHAPTER 4. METHOD OF ANALYSIS

The Empirical Models

Three variations of the farm employment model defined in chapter 2 were examined. In the most aggregative model, an employment relation for the total quantity of labor employed per farm is examined where the dependent variable is the composite quantity of family, permanent, and casual labor employed per farm. The total labor model (model 1) is:

$$L = \phi\ (X_1,\ \ldots\ X_n)$$

where L is the total quantity of labor employed per farm and $X_1, \ldots X_n$ identify the quantities of other production function variables employed per farm.

Permanent and casual labor are alternative forms of hired labor which provide human energy beyond that supplied by the family unit. The family and hired labor model (model 2), therefore, examines the parameters of the relations which specify the demand for family and hired labor--the latter being a composite of permanent and casual labor. Model 2 can be expressed as:

$$L_f = \phi\ (X_{1f},\ \ldots\ X_{nf},\ L_{hf})$$

$$L_h = \phi\ (X_{1h},\ \ldots\ X_{nh},\ P_{Lh},\ L_{fh})$$

where L_f and L_h define the quantity of family and hired labor employed per farm; $X_1, \ldots X_n$ are defined as before; and P_{Lh} is the weighted average wage paid hired labor. 32/

The family, permanent, and casual labor model (model 3) is:

$$L_f = \phi\ (X_{1f},\ \ldots\ X_{nf},\ L_{pf},\ L_{cf})$$

$$L_p = \phi\ (X_{1p},\ \ldots\ X_{np},\ P_{1p},\ L_{fp},\ L_{cp})$$

$$L_c = \phi\ (X_{1c},\ \ldots\ X_{nc},\ P_{Lc},\ L_{fc},\ L_{pc})$$

where L_f, L_p, and L_c respectively identify the quantity of family, permanent, and casual labor employed per farm; P_{Lp} and P_{Lc} identify the prices paid to permanent and casual labor; and $X_1, \ldots X_n$ are defined as before.

Estimating Techniques

Ordinary least-squares regression was used to estimate the employment parameter in the total labor model (model 1). Parameters of variables estimated for the family and hired labor model (model 2) and the family, permanent, and casual labor model (model 3) were estimated by two-stage least squares. The functional form of the equations examined was arithmetically linear. 33/

Theory and previous empirical studies suggest that the demand for family, permanent, and casual labor is jointly determined. That is, the quantity of family labor employed per farm is determined by the amount of hired labor employed, and the quantity of labor hired is determined by the quantity of family labor used.

The use of ordinary least squares to estimate coefficients in an equation that contains more than one endogenous variable yields estimates which are statistically inconsistent and biased. Methods have been developed, however, which decrease the amount of bias when large samples are used. Two of these techniques are (1) indirect least squares and (2) two-stage least squares (2SLS).

For a just-identified system of equations, indirect least squares and 2SLS produce the same results. The system of equations employed in this study is not a just-identified system. For experimental purposes, the family and hired labor model (model 2) was examined by indirect least squares and by 2SLS. The estimated employment elasticities were similar in sign and magnitude using both procedures. Since 2SLS requires less computation than indirect least squares, the former estimating procedure was employed in final analyses of the data.

A behavioral employment system in which the quantities of family, permanent, and casual labor were sequentially determined was initially examined. In such a system, the farm operator first decides how much of his and his family's labor he will use and then hires casual or permanent labor as needed to supplement the family labor. The price he must pay for hired labor services does not influence his decision concerning how much family labor will be used. The quantity of permanent labor hired is a function of those variables influencing the employment of family labor, the quantity of family labor, and the price of permanent labor. The demand for casual labor is determined by those variables influencing the employment of family labor, and the price of casual labor. This can be written algebraically as:

$$L_f = \phi\ (X_{1f}, \ldots X_{nf}, P_{Lf})$$

$$L_p = \phi\ (X_{1p}, \ldots X_{np}, P_{Lp}, L_{fp})$$

$$L_c = \phi\ (X_{1c}, \ldots X_{nc}, P_{Lc}, L_{fc}, L_{pc})$$

where each variable is defined as previously.

Preliminary examination of this model suggested that L_p and L_c were significant determinants of the amount of family labor employed per farm. Further, L_c was significant in explaining variations in the amount of permanent labor employed per farm. Each of these findings is inconsistent with the model described above. Hence, the more general or jointly determined system was estimated. 34/

Definitions of Variables

Quantity of Labor

The quantities of family (L_f), permanent (L_p), casual (L_c), hired (L_h), and total labor (L) are measured in terms of the number of 8-hour days of labor employed per farm per year. Hired labor (L_h) is the sum of permanent and casual labor employed per farm. Total labor (L) is the sum of family, permanent, and casual labor employed per farm.

Wages Paid Hired Labor

Wages paid permanent (P_{Lp}) and casual (P_{Lc}) labor are measured in rupees per day. Wages paid hired labor (P_{Lh}) are measured as the weighted average wage paid to permanent and casual labor in rupees per day.

Many farms did not employ permanent labor. On farms not employing permanent labor, the price which the farmer would have had to pay for permanent labor was assumed to be the mean wage rate for permanent labor in the farmer's village.

Farm Size

Farm size (X_1) is measured in hectares and refers to the amount of land actually cultivated. Farm size, however, does not acknowledge the expansion in area cultivated due to multiple cropping.

Irrigation

In Ferozepur, irrigation expenses (X_2) are measured in rupees and include (1) the cost of water purchased from the public irrigation system and (2) operating expenses plus depreciation on irrigation equipment owned by the farm operator. For reasons described earlier, irrigation is not included in the regression analysis for Thanjavur.

Machinery

The amount of machinery (X_5) employed per farm is measured by the current value of major and minor implements. This variable includes field implements used directly in field cultivation or harvest.

Tractors 35/

Farm records in Ferozepur did not specify tractor ownership (X_6). Nevertheless, the presence of a tractor could be deduced from the data specifying the value of major and minor implements. These data show two discrete distributions of investment in major and minor implements varying by farm size. One group, consisting of 127 farms, had an average investment in major and minor implements of Rs. 1,592 per farm. On 23 farms, none of which were smaller than 12 hectares, the average value of major and minor implements was Rs. 19,214 per farm. There is no single implement, and probably no reasonable combination of implements, other than a tractor and related equipment which can explain so large a value of farm implements.

A farm tractor can be purchased for about Rs. 15,000. Allowing for depreciation, any farm on which the reported value of major and minor implements exceeded Rs. 9,000 was defined as owning a farm tractor.

Bullock Labor

Bullock labor (X_7) is measured as the number of days of bullock labor employed per year.

Seed-Fertilizer

Originally considered as individual variables, expenditures for seed (X_8) and fertilizer (X_9) were combined because of the high degree of correlation between them. Seed-fertilizer (X_{10}) refers to the combined value of seed and fertilizer used per farm. All inorganic fertilizer as well as a large portion of the seed was purchased. The portion of seed produced on the farm was valued at current market price.

Percent HYV

Percent HYV (X_{19}), in Ferozepur, refers to the percentage of total wheat area sown to high-yielding varieties. In Thanjavur, percent HYV refers to the percentage of Kuruvai rice area sown to ADT-27.

The Models Tested in Regression

In addition to examining farm employment with the farm unit as the basic reference point, the regression models were examined with variables specified on a per hectare basis. In the former, variables were measured over the entire farm unit. In the latter, each variable measured over the farm unit was divided by the net area cultivated (X_1) for the respective farm enterprise.

The "Per Farm" Models

Three employment models were used to estimate employment relationships on two cross sections of farmers--one for Ferozepur and one for Thanjavur farms.

Total Labor (Model 1).--The function applied to both cross sections in the per farm version of model 1 is:

$$(1) \quad L = a + \Sigma\, b_i X_i + e$$

where

- L: human labor (days)
- a: the constant term
- X_1: farm size (hectares)
- X_2: irrigation (rupees) 36/
- X_5: machinery (rupees)
- X_7: bullock labor (days)
- X_{10}: seed-fertilizer (rupees)
- X_{19}: percent HYV
- e: the error term.

Family and Hired Labor (Model 2).--The functions by which the per farm version of model 2 was estimated are:

$$(2) \quad L_f = a_f + \Sigma\, b_{if} X_{if} + b_{L_{hf}} L_{hf} + e_f$$

$$L_h = a_h + \Sigma\, b_{ih} X_{ih} + b_{P_{Lh}} P_{Lh} + b_{L_{fh}} L_{fh} + e_h$$

where

- L_f: family labor (days)
- L_h: hired labor (days)
- P_{Lh}: price of hired labor (rupees per day).

The variables a, X_i, and e are defined as before. The subscripts f and h identify the equations for family (f) and hired (h) labor.

Family, Permanent, and Casual Labor (Model 3).--The equations used to estimate the per farm version of model 3 are:

$$(3) \quad L_f = a_f + \Sigma\, b_{if}X_{if} + b_{L_{pf}} L_{pf} + b_{L_{cf}} L_{cf} + e_f$$

$$L_p = a_p + \Sigma\, b_{ip}X_{ip} + b_{P_{Lp}} P_{Lp} + b_{L_{fp}} L_{fp} + b_{L_{cp}} L_{cp} + e_p$$

$$L_c = a_c + \Sigma\, b_{ic}X_{ic} + b_{P_{Lc}} P_{Lc} + b_{L_{pc}} L_{pc} + b_{L_{pc}} L_{pc} + e_c$$

L_f: family labor (days)

L_p: permanent labor (days)

L_c: casual labor (days

P_{Lp}: price of permanent labor (rupees per day)

P_{Lc}: price of casual labor (rupees per day)

The variables a, X_i, and e are defined as before. The subscripts f, p, and c identify the equations for family (f), permanent (p), and casual (c) labor.

The "Per Hectare" Models

The per hectare models differ from the per farm models only insofar as X_i ($i \neq 1, 19$), L, L_f, L_h, L_p, and L_c are divided by X_1. The variables X_1, X_{19}, and P_{Lh} were not divided by X_1. Also, as in the per farm version, the models illustrated below apply equally to Ferozepur and Thanjavur. Since the per hectare version of model 3 yielded results which were statistically unsatisfactory, only the per hectare versions of models 1 and 2 are presented. 37/

Total Labor (Model 1a).--The function used to examine the per hectare version of model 1 is:

$$(1a) \quad \frac{L}{X_1} = a + b_1X_1 + \Sigma\, b_i \frac{X_i}{X_i} + b_{19} X_{19} + e$$

where the variables L, a, X_i, and e are defined as in model 1 before.

Family and Hired Labor (Model 2a).--The functions for the per hectare version of model 2 are:

$$\text{(2a)}\quad \frac{L_f}{X_1} = a_f + b_{1f}X_{1f} + \Sigma\, b_{if}\frac{X_{if}}{X_{1f}} + b_{19f}X_{19f} + b_{L_{hf}}\frac{L_{hf}}{X_{1f}} + e_f$$

$$\frac{L_h}{X_1} = a_h + b_{1h}X_{1h} + \Sigma\, b_{ih}\frac{X_{ih}}{X_{1h}} + b_{19h}X_{19h} + b_{P_{L_{hh}}} P_{L_{hh}} + b_{L_{hh}}\frac{L_{hh}}{X_{1h}} + e_h$$

where the variables L_f, L_h, P_{Lh}, a, X_i, and e are defined as in model 2 before.

CHAPTER 5. STATISTICAL RESULTS

Total Labor Model (Model 1)

Model 1 examined factors influencing the total amount of labor employed per farm (or per hectare). The results obtained from model 1 regressions for Ferozepur and Thanjavur are reported in table 5.1. Matrices of simple correlation coefficients among the independent variables are in appendix A (tables A.3, A.4, A.5, and A.6). The coefficient of multiple determination, R^2, for each equation exceeds 0.60. With the exception of machinery and percent HYV, all variables are significantly different from zero at the 0.10 level or greater, and the parameter estimates are consistent with economic logic. All variables reported in the text as statistically significant are significant at the 0.10 level or more. The specific significance levels for particular variables can be identified from the respective tables in which regression results are reported.

Model 1: Per Farm Version

The employment elasticity for total labor with respect to seed-fertilizer was significant in both Thanjavur and Ferozepur. In Thanjavur, it was significantly greater (almost twice as large) than that estimated in Ferozepur. 38/

The employment elasticities for total labor with respect to farm size and bullock labor were statistically significant in both districts. Further, in both districts a 1-percent increase in farm size or bullock labor was associated with an increase of approximately one-fourth of 1 percent in total labor employed per farm.

In Ferozepur, the total amount of labor employed per farm was not significantly related to the amount of machinery used per farm. The amount of labor employed per farm in Thanjavur was statistically significant and was positively related to the value of farm machinery. Nevertheless, in Thanjavur the employment elasticity with respect to farm machinery was extremely small. A 1-percent increase in the value of farm machinery per farm in Thanjavur tended to increase the total amount of farm labor employed by only 0.02 percent.

The proportion of the major crop under high-yield varieties was not significantly related to the total amount of labor employed per farm. This lack of association also appears in the results obtained in models 2 and 3.

Model 1: Per Hectare Version

In both districts, the total amount of labor employed per hectare was negatively related to farm size. The employment elasticities are about -0.10, and indicate that a 1-percent increase in net area cultivated was associated

Table 5.1--Regression coefficients, standard errors, and employment elasticities for farm labor per farm and per hectare, model 1, Ferozepur and Thanjavur, 1967/68

Independent variable	Per farm version (model 1)				Per hectare version (model 1a)			
	Ferozepur		Thanjavur		Ferozepur		Thanjavur	
	Regression coefficient (stand. error)	Employment elasticity	Regression coefficient (stand. error)	Employment elasticity	Regression coefficient (stand. error)	Employment elasticity	Regression coefficient (stand. error)	Employment elasticity
Constant	184.7878	---	47.3934	---	41.5516	---	33.2345	---
Farm size	1/ 16.1709* (4.4182)	0.2307	19.7592* (3.9282)	0.2623	-.7727* (.2105)	-0.1241	-1.0184* (.4025)	-0.0821
Irrigation	.2615* (.0574)	.1579	---	---	.1283* (.0417)	.0776	---	---
Machinery	.0011 (.0028)	.0054	.0214* (.0076)	.0211	-.0017 (.0020)	.0067	.0121 (.0228)	.0078
Bullock labor	.8112* (.1569)	.2128	.6464* (.1710)	.2591	.9371* (.1231)	.2645	.5196* (.1028)	.2185
Seed-fertilizer	.0875* (.0235)	.1871	.2730* (.0451)	.3353	.1400* (.0248)	.2651	.3347* (.0328)	.3994
Percent HYV	-.0891 (.8100)	-.0030	.2105 (.7016)	.0322	-.0140 (.0583)	-.0054	-.0624 (.0931)	-.0580
R^2	.694	---	.800	---	.626	---	.797	---
f	54.237	---	14.194	---	39.914	---	93.433	---
s	279.046	---	255.898	---	19.468	---	30.067	---

1/ The asterisk identifies those variables whose coefficients are statistically significant at the 0.10 level or more.

with a 0.10-percent decrease in farm labor employed per hectare. These relationships are consistent with those illustrated in table 3.5.

Variation in the amount of bullock labor employed per hectare was, in both districts, a statistically significant determinant of total labor employed per hectare. In both districts, the employment elasticity for total labor employed per hectare with respect to bullock labor per hectare was approximately 0.20.

Compared with the other variables included in the per hectare version of the total labor model, variations in expenditures for seed-fertilizer per hectare, in both districts, had the largest positive employment elasticity. As in the per farm version of model 1, the employment elasticity with respect to seed-fertilizer per hectare in Thanjavur was significantly greater than that observed in Ferozepur (table A.7). The amount of labor employed per hectare was not significantly related to the proportion of major crop under high-yield variety or the value of farm machinery per hectare.

Family and Hired Labor Model (Model 2)

Model 2 was used to examine factors influencing the employment of family and hired labor. The per farm version of model 2 explained 0.71 and 0.78 of the variation in the amount of hired labor employed per farm in Ferozepur and Thanjavur, respectively. Only a small portion of the variation in the amount of family labor employed per farm was explained in the context of model 2 in each district.

The per hectare version of model 2 explained 0.72 of the variation in the amount of hired labor employed per hectare in Thanjavur, but explained only a small portion of the variation in the amount of family labor employed per hectare. In Ferozepur, the per hectare version of model 2 was statistically inferior to the per farm version. The R^2's were small, and only two variables in the family labor equation and only one variable in the hired labor equation were statistically significant. Consequently, the results of the per hectare version of model 2 for Ferozepur are reported in appendix table A.8, but are not further discussed in the text.

Model 2, Ferozepur: Per Farm Version

The results of the per farm version of model 2 are contained in table 5.2. Simple correlation matrices are presented in appendix tables A.3 to A.6.

Family Labor.--On Ferozepur farms, only 16 percent of the variation in the amount of family labor employed per farm was explained. Bullock labor was the only statistically significant variable in the family labor equation in model 2. 39/

Table 5.2--Regression coefficients, standard errors, and employment elasticities for family and hired labor per farm, model 2, two-stage least-squares regression, Ferozepur and Thanjavur, 1967/68

Independent variable	Ferozepur District				Thanjavur District			
	Family labor		Hired labor		Family labor		Hired labor	
	Regression coefficient (stand. error)	Employment elasticity	Regression coefficient (stand. error)	Employment elasticity	Regression coefficient (stand. error)	Employment elasticity	Regression coefficient (stand. error)	Employment elasticity
Constant............	248.9555	---	222.1595	---	113.0796	---	74.5665	---
Farm size...........	-12.9471 (11.2583)	-0.4325	1/ 16.7472* (3.9800)	0.4171	3.4781* (1.7477)	0.1946	36.9103* (4.8502)	0.6421
Irrigation..........	.0820 (.0891)	.1160	.2505* (.0525)	.2640	---	---	---	---
Machinery...........	.0006 (.0026)	.0072	.0011 (.0023)	.0098	.0008 (.0030)	.0035	.0161* (.0075)	.0208
Bullock labor........	.5143* (.1863)	.3158	.7652* (.1689)	.3503	.0620 (.0729)	.1048	.7835* (.1729)	.4116
Seed-fertilizer......	.0256 (.0336)	.1284	.0882* (.0221)	.3295	.0628* (.0207)	.3254	.5935* (.0710)	.9553
Percent HYV.........	-.4061 (.7520)	-.0323	.1381 (.6905)	.0082	-.4404 (.2701)	-.2841	-.1190 (.7000)	-.0238
Wage, hired labor....	---	---	-12.9804 (12.2456)	-.1264	---	---	-27.3254 (35.9544)	-.1943
Family labor.........	---	---	-.9266* (.1898)	-.6908	---	---	-8.5777* (1.3278)	-.0267
Hired labor..........	.1770 (.4317)	.2374	---	---	-.0776 (.0494)	-.2499	---	---
R^2.................	.163	---	.711	---	.215	---	.781	---
f..................	3.973	---	43.426	---	7.547	---	75.685	---
s..................	254.588	---	233.022	---	87.087	---	220.623	---

1/ The asterisk identifies those variables whose coefficients are statistically significant at the 0.10 level or more.

This, however, is of trivial interest because bullock labor is generally regarded as an input which is complementary with human labor (69, p. 43). Of greater interest are the underlying factors which, by inducing movement along a given production surface or from one production surface to another, influence the employment of both family and bullock labor. No such insights were obtained from the family labor equation in model 2.

The most significant aspect of the family labor portion of model 2 is the lack of ability to explain variations in the amount of family labor employed per farm. There are two reasons for the low explanatory power of the family labor equation. First, imprecise measurement of the dependent variable is a clear possibility. Of greater interest is the possibility that the quantity of family labor employed per farm varies as a function of a number of factors beyond those which could be empirically examined with the data available. This latter aspect is further considered in the following chapter.

Hired Labor.--In Ferozepur, all variables except machinery, percent HYV, and wage paid hired labor significantly influenced the amount of hired labor employed. Further, all variables contained signs consistent with a priori expectations.

The employment elasticity for hired labor with respect to farm size is 0.40. That is, a 1-percent increase in farm size was associated with a 0.40-percent increase in hired labor employed per farm. Also, hired labor was significantly related to variations in irrigation, bullock labor, and seed-fertilizer. The resulting employment elasticities, while positive, were slightly smaller than those derived with respect to farm size. The employment elasticity for hired labor with respect to family labor was significant and strongly (-0.69) negative. This suggests that hired labor substituted for, rather than supplemented, family labor.

The employment elasticity with respect to the price paid to hired labor, while negative, was not statistically significant.

The amount of hired labor employed per farm appears to be more significantly related to variations in production variables than is family labor. Employment elasticities for hired labor with respect to each of the production function variables were greater in positive value than corresponding elasticity estimates for family labor. The positive employment elasticities for hired labor with respect to (1) farm size and (2) seed-fertilizer were significantly greater than the corresponding elasticities for family labor (table A.10). This is corroborated by the fact that the employment elasticities for hired labor with respect to farm size, irrigation, bullock labor, and seed-fertilizer were significantly greater than those estimated for total labor in the per farm version of model 1 for Ferozepur in table 5.1 (table A.11). Increased use of inputs commonly associated with the "green revolution" seems to have had a greater short-run employment effect on hired labor than on family labor.

Model 2, Thanjavur: Per Farm Version

Family Labor.--Less than 0.25 of the variation in the amount of family labor employed per farm in Thanjavur was explained in model 2. Both farm size and seed-fertilizer were statistically significant determinants of the amount of family labor employed per farm. The signs on each variable were positive and consistent with a priori expectations. In Thanjavur, as in Ferozepur, the most significant result of the family labor relation is the apparent inability to explain a major portion of the variation in family labor employed per farm.

Hired Labor.--All variables except percent HYV and wage paid hired labor were significantly different from zero. Further, all variables except percent HYV had signs consistent with a priori expectations. Of particular interest are the estimated elasticities with respect to farm size, bullock labor, and seed-fertilizer. The employment elasticities for hired labor with respect to each of the above variables were significantly greater than those for family labor (table A.10). The employment elasticity for hired labor per farm with respect to seed-fertilizer (0.95) was almost three times as great as that estimated for family labor.

The employment elasticity for hired labor with respect to farm machinery was significant and positive. The elasticity coefficient with respect to farm machinery, however, was extremely small (0.02). Hence, the amount of hired labor employed per farm was only slightly affected by the amount of farm machinery on a given farm.

A negative and highly significant employment elasticity for hired labor with respect to family labor suggests that hired labor was a substitute for, rather than supplementary to, family labor. The estimated elasticity was quite small (-0.02), however, and implies that this relationship was small. Also, the employment elasticity for hired labor with respect to its own price, while negative, was not statistically significant.

Hired Labor Compared: Ferozepur and Thanjavur

Increases in production variables apparently had a greater proportionate employment effect on hired labor in Thanjavur than in Ferozepur. The employment elasticities for hired labor with respect to farm size and seed-fertilizer were significantly larger in Thanjavur than in Ferozepur (table A.12). The employment elasticity for hired labor with respect to seed-fertilizer in Thanjavur was three times as great as that observed in Ferozepur.

The wage rate paid hired labor was not a significant determinant of the total amount of hired labor employed per farm in either district. Finally, the negative employment elasticity for hired labor with respect to family labor was significantly smaller in Thanjavur than in Ferozepur (table A.12). This suggests that family labor was much less a substitute for hired labor in Thanjavur than in Ferozepur.

Model 2, Thanjavur: Per Hectare Version

The results of the per hectare version of model 2 as applied to Thanjavur are presented in table 5.3. Simple correlation matrices are presented in appendix table A.6.

Table 5.3--Regression coefficients, standard errors, and employment elasticities for family and hired labor per hectare, model 2, two-stage least squares, Thanjavur, 1967/68

Independent variable	Family labor per hectare: Regression coefficient (std. error)	Family labor per hectare: Employment elasticity	Hired labor per hectare: Regression coefficient (std. error)	Hired labor per hectare: Employment elasticity
Constant	33.6960	---	138.8999	---
Farm size	1/ -1.3305* (.2996)	-0.3512	3.9029* (1.0243)	0.4528
Machinery	.0319* (.0171)	.0675	.0851* (.0347)	.0793
Bullock labor	.2105* (.1156)	.2900	.7374* (.1378)	.4466
Seed-fertilizer	.1082 (.0698)	.4227	.4405* (.0457)	.7567
Percent HYV	-.1074 (.0675)	-.3267	-.2908* (.1281)	-.3889
Wage, hired labor	---	---	-13.5679* (5.2386)	-.6435
Family labor	---	---	-3.0321* (.6548)	-1.3322
Hired labor	-.2209 (.2277)	-.5026	---	---
R^2	.326	---	.716	---
f	9.745	---	44.094	---
s	21.341	---	32.382	---

1/ The asterisk identifies those variables whose coefficients are statistically significant at the 0.10 level or more.

Family Labor.--Only a small portion of the variation in family labor employed per hectare (R^2=0.33) was explained by the per hectare version of model 2. Three variables (farm size, farm machinery per hectare, and bullock labor per hectare), however, were significantly related to the quantity of family labor employed. The signs of the significant variables are consistent with a priori expectations. Also, in the per hectare version of model 2, the signs on the significant variables in the family labor equation coincide with those obtained in the per hectare versions of model 1 for Thanjavur (table 5.1).

The employment elasticity for family labor with respect to farm size was negative, and was significantly larger in absolute value than the comparable elasticity for total labor in the per hectare version of model 1 (table 5.1). However, while statistically significant, the employment elasticity for family labor per hectare with respect to machinery per hectare was quite small. Finally, the employment elasticity for family labor per hectare with respect to bullock labor per hectare, estimated to be approximately 0.30, was smaller than that estimated for total labor (0.44) per hectare (table 5.1).

Seed-fertilizer--a variable which was a highly significant determinant of the amount of total labor (table 5.1) and hired labor (table 5.2) employed per farm and per hectare--was not a significant determinant of the amount of family labor employed per hectare.

Hired Labor.--The per hectare version of model 2 explained 0.71 of the variation in hired labor employed per hectare. All variables were significantly different from zero. Moreover, all variables except percent HYV had signs consistent with a priori expectations.

Seed-fertilizer per hectare was the most significant variable. The employment elasticity associated with this variable was 0.75. As compared with other inputs examined in this study, the size of the employment elasticity for hired labor with respect to seed-fertilizer is an important finding. In this and previous computations, variations in the amount of seed-fertilizer used per hectare (or farm) had a relatively large influence on the amount of hired labor employed.

Noteworthy, also, is the magnitude of the employment elasticity with respect to farm size. A 1-percent increase in the number of hectares cultivated per farm was associated with an increase of almost 0.50 percent in the amount of hired labor employed per hectare.

The employment elasticity for hired labor with respect to bullock labor per hectare was slightly larger than the similar coefficient for family labor per hectare. The employment elasticity for hired labor per hectare with respect to farm machinery per hectare was almost identical to that estimated for family labor per hectare.

The wage rate paid hired labor was negative and significantly different from zero. Thus, variation in the wage, while not a significant determinant of the amount of hired labor employed per farm, was significantly related to the amount of hired labor employed per hectare.

The employment elasticity for hired labor per hectare with respect to the amount of family labor employed per hectare was negative, significant, and greater than one in absolute value. Thus, while the substitution relationship between family and hired labor measured on a per farm basis was quite small, the substitution relationship between these two measured on a per hectare basis was quite large.

The negative elasticity for hired labor per hectare with respect to percent HYV is inconsistent with a priori expectations. No plausible explanation for this coefficient, which is significantly different from zero, is obvious.

Family and Hired Labor Compared.--The employment elasticities for hired labor per hectare with respect to variations in all production function variables were larger than those obtained for family labor. While all the employment elasticities for hired labor were larger than that estimated for hired labor only the employment elasticity for hired labor with respect to farm size was significantly greater than that estimated for family labor (table A.13).

Family, Permanent, and Casual Labor Model (Model 3)

Model 3 examined factors influencing the employment of family, permanent, and casual labor. Because model 3 is more specific with respect to the kind of hired labor used on farms, regressions using model 3 detected a larger amount of random disturbances associated with imperfections in the market for particular kinds of hired labor. This is reflected in two ways. First, the R^2's for permanent and casual labor estimated in model 3 are somewhat lower than those obtained for hired labor in model 2. Second, the production function variables yield some of their explanatory power to indexes of local labor market conditions. These indexes were measured by variations in wage rates paid to the two kinds of hired labor.

As in model 2, only a small portion of the variation in family labor employed per farm was explained by model 3 regressions estimating the employment relation for family labor.

Model 3, Ferozepur

The results of the model 3 regressions on Ferozepur farms are reported in table 5.4. Matrices of simple correlation coefficients are presented in table A.4. Model 3 explained 0.70 and 0.55 of the variation in the amount of casual and permanent labor used per farm, respectively. However, only 0.17 of the variation in family labor used per farm was explained by this model.

Family Labor.--The most significant aspect of the family labor relation in model 3, as in model 2, was the apparent lack of statistical fit. The small R^2, plus the fact that none of the independent variables were significantly different from zero, implies that a more complex structural employment relationship exists for family labor than that examined in this study. These possibilities are considered in the next chapter.

Table 5.4--Regression coefficients, standard errors, and employment elasticities for family, permanent, and casual labor per farm, model 3, two-stage least squares, Ferozepur, 1967/68

Independent variable	Family labor		Permanent labor		Casual labor	
	Regression coefficient (std. error)	Employment elasticity	Regression coefficient (std. error)	Employment elasticity	Regression coefficient (std. error)	Employment elasticity
Constant	326.0567	---	78.6614	---	115.205	---
Farm size	-23.6221 (22.7135)	-0.7891	9.2197 (6.1877)	0.4253	1/ 25.9754* (9.3101)	0.1406
Irrigation	-.0782 (.3128)	-.1106	.1582* (.0479)	.3089	.3155* (.1303)	.7230
Machinery	.0042 (.0071)	.0472	-.0012 (.0023)	-.0186	-.0018 (.0028)	-.0343
Bullock labor	.1471 (.7004)	.0903	.4610* (.1431)	.3909	.8512* (.3007)	.8472
Seed-fertilizer	-.0638 (.1678)	-.3193	.0693* (.0176)	.4790	.1514* (.0710)	1.2284
Percent HYV	-.2870 (.7972)	-.0228	.2821 (.5877)	.0310	.2303 (.3337)	-.0296
Wage, permanent labor	---	---	-8.6256 (10.6488)	-.1741	---	---
Wage, casual labor	---	---	---	---	-22.2236* (4.8207)	-.4765
Family labor	---	---	.3899* (.1617)	-.5382	-.5031* (.0914)	-.8154
Permanent labor	1.6149 (3.2298)	1.1696	---	---	-1.9964* (1.1279)	-2.3437
Casual labor	.1159 (.4636)	.0715	-.2249 (.3407)	-.1916	---	---
R^2	.166	---	.550	---	.700	---
f	3.495	---	19.021	---	36.304	---
s	265.249	---	196.350	---	111.300	---

1/ The asterisk identifies those variables whose coefficients are statistically significant at the 0.10 level or more.

Permanent Labor.--Irrigation, bullock labor, seed-fertilizer, and family labor were significant determinants of the amount of permanent labor employed per farm. Also, the signs on the elasticities for permanent labor with respect to these variables were consistent with a priori expectations.

Machinery, as in models 1 and 2, was not a factor which significantly influenced the amount of permanent labor employed per farm. However, in model 3, farm size (a statistically significant variable in the total labor model and the hired labor equation in model 2) was not a significant determinant of the quantity of permanent labor employed per farm. Variations in the wages paid permanent labor, while consistent in sign with a priori expectations, were not a significant determinant of permanent labor employment.

The negative employment elasticity for permanent labor with respect to family labor is consistent with that estimated for hired labor in model 2. This indicates that permanent labor substituted for, rather than supplemented, family labor. The employment elasticity for permanent labor with respect to casual labor, while negative, was not significantly different from zero. This suggests that the quantity of permanent labor hired was not dependent on the quantity of casual labor employed.

Casual Labor.--All variables except percent high-yield variety were significant determinants of the amount of casual labor employed per farm. Also, the direction of influence of each significant variable is consistent with a priori expectations.

The employment elasticity for casual labor with respect to farm size is only 0.14. Hence, proportional variations in farm size were associated with rather small proportional changes in casual labor employed per farm. However, the employment elasticities for casual labor with respect to irrigation, bullock labor, and seed-fertilizer are large (0.72, 0.85, and 1.23 respectively) relative to estimates obtained in models 1 and 2 and for other forms of farm labor specified in table 5.4. The elasticity estimates for casual labor with respect to the above variables were significantly greater than those estimated for permanent labor (table A.15). 40/

In contrast to permanent labor, variations in the wage rate paid casual labor significantly influenced the amount of casual labor employed per farm. A 1-percent rise in wage rates paid casual labor was associated with a 0.50-percent decline in the amount of casual labor employed per farm.

If, as indicated above, farmers respond to variations in wage rates for casual labor, then what forms of energy are substituted for casual labor? The employment elasticity for casual labor with respect to farm machinery, while negative, was not significantly different from zero at the 0.10 level. Hence, one cannot conclude that farm machinery furnished the substitute forms of farm energy. The employment elasticities for casual labor with respect to family labor (-0.82) and permanent labor (-2.34) were statistically significant, however. Substitute forms of farm energy for casual labor, therefore, seem to come primarily from permanent labor and to a lesser degree from family labor.

Model 3, Thanjavur

The results of the model 3 regressions on Thanjavur farms are presented in table 5.5. Matrices of simple correlation are presented in table A.16. About 0.47 and 0.78 of the variation in permanent and casual labor employed per farm was explained in this model. Less than 0.30 of the variation in family labor employed per farm was explained.

Family Labor.--In spite of the low explanatory power of the family labor equation, all variables except farm size and percent HYV were statistically significant. Further, the coefficient for each significant variable was consistent in sign with a priori expectations.

The employment elasticities for family labor with respect to bullock labor and seed-fertilizer were 0.38 and 0.28, respectively. The employment elasticity for family labor with respect to farm machinery was -0.05. This result is somewhat surprising in that the relationship between family labor and farm machinery was not expected to be statistically significant. However, the employment elasticity with respect to farm machinery, while statistically significant, was very small.

The amount of family labor employed per farm was negatively and significantly related to the quantity of permanent and casual labor employed. Casual labor, which if increased by 1 percent was associated with a decrease of 0.74 percent in family labor per farm, substitutes for family labor.

Family labor, however, is positively related to the amount of permanent labor employed per farm. This could imply that family labor is supplementary to permanent labor. This interpretation, however, is inconsistent with the probable relationship between family and permanent labor in the farm enterprise. Farmers hire farmworkers only when the quantity of labor supplied by the farm family is insufficient to satisfy total labor requirements. This does not imply, however, that farmers furnish additional amounts of their own labor only when hired labor is insufficient. Nor is the former interpretation consistent with the view that family labor is the residual claimant of farm income and the initial source of human labor in the farm enterprise.

A more realistic interpretation of the positive employment elasticity for family labor with respect to permanent labor suggests that permanent labor is supplementary to family labor.

Permanent Labor.--While nearly one-half of the variation in permanent labor employed per farm was explained in model 3, only two variables were statistically significant. Further, the standard error of the regression equation was 1.3 times the arithmetic mean of the dependent variable. 41/

Table 5.5--Regression coefficients, standard errors, and employment elasticities for family, permanent, and casual labor per farm, model 3, two-stage least squares, Thanjavur, 1967/68

Independent variable	Family labor		Permanent labor		Casual labor	
	Regression coefficient (std. error)	Employment elasticity	Regression coefficient (std. error)	Employment elasticity	Regression coefficient (std. error)	Employment elasticity
Constant	107.7761	---	-126.5813	---	205.6076	---
Farm size	2.1694 (1.7495)	0.1214	4.5143 (5.1888)	0.4685	6.1164 (6.7960)	0.1278
Machinery	1/ -.0118* (.0059)	-.0493	.0162* (.0035)	.1250	-.0399* (.0112)	-.0621
Bullock labor	.2260* (.1046)	.3820	-.1515 (.1500)	-.4748	.7969* (.1503)	.5029
Seed-fertilizer	.0540* (.0203)	.2797	.0583 (.0844)	.5602	.1373 (.1017)	.2654
Percent HYV	-.3576 (.2709)	-.2307	.0123 (.3075)	.0148	.5276 (.6134)	.1271
Wage, permanent labor	---	---	73.1291* (29.1350)	1.1763	---	---
Wage, casual labor	---	---	---	---	-25.8275 (27.4760)	-.2261
Family labor	---	---	-.6150 (1.3369)	-1.1408	-2.2315 (1.5939)	-.8337
Permanent labor	.6893* (.3176)	.3718	---	---	2.4022* (.5705)	.4838
Casual labor	-.2749* (.1049)	-.7380	.1556 (.1540)	.7856	---	---
R^2	.264	---	.470	---	.778	---
f	7.243	---	15.521	---	61.322	---
s	86.079	---	103.952	---	191.264	---

1/ The asterisk identifies those variables whose coefficients are significant at the 0.10 level or more.

Farm machinery was positively related to the amount of permanent labor employed per farm. This result is plausible given the complementary nature of farm implements used on farms in Thanjavur. Neither farm size, bullock labor, nor seed-fertilizer were statistically significant variables. This latter feature suggests caution in reading economic meaning into the employment elasticity for permanent labor with respect to farm machinery.

The most unexpected result of the regression relation for permanent labor was the positive elasticity with respect to wages paid permanent labor. This statistically significant result is inconsistent with the theory specifying the derived demand for a factor of production. This coefficient can, however, be rationalized in two ways within the context of the market for Pannaiyal labor as described in chapter 2. First, the positive employment elasticity for permanent labor may merely be an index measure of the operation of a traditional labor market which operates on premises other than those on which the theory of derived input demand rests. Second, the positive elasticity could indicate that permanent labor in Thanjavur is not a homogeneous commodity. Farmers using large amounts of permanent labor are using laborers other than Pannaiyal laborers. These workers, perhaps reported to be permanent laborers, are more productive workers and consequently are paid a higher wage. Both of these rationalizations, however, are highly speculative. Nevertheless, the positive sign on the wage rate coefficient for permanent labor is quite likely related to institutional peculiarities associated with the market for Pannaiyal labor.

The regression results for permanent labor in Thanjavur may have been caused by the fact that only 46 percent of the sample farms employed permanent laborers. Consequently, the value of the dependent variable (permanent labor) was zero on 54 percent of the farms examined. The lack of continuous variation in the dependent variable over such a large number of observations implies that the peculiar results may be caused by statistical rather than economic peculiarities.

To more fully explore this aspect, model 3 was again tested on those 68 farms which employed both permanent and casual labor (table A.17). The results of this analysis closely approximate those obtained in table 5.5 and are not described in detail. Of particular interest, however, is the fact that the employment elasticity for permanent labor with respect to the wage paid permanent labor (table A.17) was statistically significant and positive in sign. The elasticity for permanent labor with respect to the wage paid permanent labor was 1.17 in table 5.5 and 1.95 in table A.17. These results support the contention that the unexpected price elasticity observed for permanent labor in Thanjavur is a manifestation of the Pannaiyal labor market.

Casual Labor.--Almost 0.80 of the variation in the amount of casual labor employed per farm was explained by model 3. Most of the variation in casual labor employed per farm was explained by three variables--farm machinery, bullock labor, and permanent labor. The signs on the employment elasticities with respect to these variables are consistent with a priori expectations.

The employment elasticity for casual labor with respect to farm machinery, while statistically significant and negative, was small. A 1-percent increase in the value of farm machinery was associated with a 0.06-percent decline in casual labor used per farm. The employment elasticity of 0.50 for casual labor with respect to bullock labor is comparable with previous estimated elasticities with respect to bullock labor. However, the amount of casual labor employed per farm was not significantly related to either farm size or seed-fertilizer.

The wage rate paid casual labor was not significantly related to the quantity of casual labor employed per farm, but the sign on the employment elasticity for casual labor with respect to the wage paid casual labor was negative. The lack of statistical significance of the wage rate variable is consistent with that expected in this densely populated district. Thanjavur District, with its high population density, large number of rural farm laborers relative to the total farm labor force, and relatively small average farm size, contains many characteristics commonly associated with a surplus labor economy. The negative sign on the wage rate variable for casual labor indicates that casual labor (in contrast to the Pannaiyal labor market) in Thanjavur is employed via a market mechanism which behaves according to the premises of a market-oriented economy.

The employment elasticity for casual labor with respect to permanent labor was significant and positive. In addition, the employment elasticity for permanent labor with respect to casual labor, while not statistically significant, was also positive. These results are interpreted as indicating that casual labor is used in production activities for somewhat different purposes than permanent labor.

Evaluation of the Models

The experimental procedures employed in this study are based on an underlying hypothesis that the decision framework for allocating family and hired labor on farms in India is a simultaneous rather than a recursive relationship. A recursive relationship is one in which the decision of how much family labor will be supplied is made prior to and independent of the decision to employ hired labor.

In a simultaneous decision system, the amount of family labor employed per farm is determined jointly with the decision regarding how much hired labor will be employed per farm. In regression, therefore, the demand for family labor is partially explained by variations in the amount of hired labor. 42/

In the 2SLS, family labor was not observed to be functionally dependent on variations in the amount of hired labor employed per farm (tables 5.2, 5.4, and 5.5). 43/ Consequently, the results do not conclusively show that the underlying structural relationship was more accurately described by a simultaneous rather than a recursive system. Nevertheless, this does not indicate that a recursive system offers a more satisfactory conceptual vehicle. In the initial experiment in regression, the substitution variables were statistically significant and offered evidence to the contrary. Hence, future examinations of farm employment relationships should be set in the context of a simultaneously determined structural system.

CHAPTER 6. ECONOMIC ANALYSIS OF DETERMINANTS OF FARM EMPLOYMENT

This section evaluates the results of the regression analyses in light of the hypothesized influence of each independent variable on farm employment (see chapter 2). On the basis of this analysis, a decision can be made with respect to the actual effect of the independent variables on farm employment. Tables 6.1 and 6.2, which summarize the employment elasticities derived in each model, form the basis for the discussion which follows.

Farm Size

Farm size was hypothesized to be positively related to the amount of family, hired, and total labor employed per farm. The results of the regression analysis show that farm size is an important determinant of (1) the total amount of labor and (2) the amount of hired labor employed per farm. In Ferozepur, the total amount of labor employed per hectare decreased as farm size increased. This tendency was apparently offset by an aggregate increase in demand for labor as farm size increased. The significant and positive employment elasticities with respect to farm size support the hypothesis that the total amount of labor and the amount of hired labor employed per farm are positively related to farm size.

Because of suspected upper limits on the supply of family labor, farm size was expected to have a greater effect on employment of hired labor than on family labor. In both districts, the employment elasticities for family labor with respect to farm size was inconsistent in sign and, with one exception, not statistically significant. This is partially related to the fact that family size tends to increase less than in proportion to increases in farm size. The statistical results, therefore, tend to support the hypothesized relationship between farm size and employment of family labor.

Irrigation

Irrigation was expected to be positively related to the amount of labor employed per farm. In Ferozepur, variations in irrigation expenses were statistically significant in explaining variations in the amounts of total, total hired, permanent, and casual labor employed per farm and per hectare. The significant and positive employment elasticities with respect to irrigation expenses lend empirical support to the hypothesized effect of irrigation on employment.

Family labor, however, was not significantly related to variations in irrigation expenses. Further, family labor was not significantly influenced by variations in the use of most production function variables. Consequently,

Table 6.1--Summary of employment elasticities estimated in per farm version of models 1, 2, and 3, Ferozepur, 1967/68 1/

Independent variable	Model 1: Total labor	Model 2		Model 3		
		Family labor	Hired labor	Family labor	Permanent labor	Casual labor
Farm size	2/0.2307*	-0.4325	0.4171*	-0.7891	0.4253	0.1406*
Irrigation	.1579*	.1160	.2640*	-.1106	.3089*	.7230*
Machinery	.0054	.0072	.0098	.0472	-.0186*	-.0343
Bullock labor	.2128*	.3158*	.3503*	.0903	.3909*	.8472*
Seed-fertilizer	.1871*	.1248	.3295*	-.3193	.4790*	1.2994*
Percent HYV	-.0030	-.0323	.0082	-.0228	.0310	-.0296
Price of labor	---	---	-.1264	---	-.1741	-.4765*
Family labor	---	---	-.6908*	---	-.5382*	-.8154*
Hired labor	---	.2374	---	---	---	---
Permanent labor	---	---	---	1.1696	---	-2.3437*
Casual labor	---	---	---	.0715	-.1916	---

1/ Sources: Tables 5.1, 5.2, and 5.4.
2/ The asterisk identifies those elasticities derived from regression coefficients which were statistically significant at the 0.10 level or more.

Table 6.2--Summary of employment elasticities estimated in per farm version of models 1, 2, and 3 Thanjavur, 1967/68 1/

Independent variable	Model 1: Total labor	Model		Model 3		
		Family labor	Hired labor	Family labor	Permanent labor	Casual labor
Farm size................	2/0.2623*	0.1946*	0.6421*	0.1214	0.4685	0.1278
Machinery................	.0211*	.0035	.0208*	-.0493*	.1250*	-.0621*
Bullock labor............	.2591*	.1048	.4116*	.3820*	-.4748	.5029*
Seed-fertilizer..........	.3353*	.3254*	.9553*	.2797*	.5602	.2654
Percent HYV..............	.0322	-.2841	-.0238	-.2307	.0148	.1271
Price of labor...........	---	---	-.1943	---	1.1763*	-.2261
Family labor.............	---	---	-.0267	---	-1.1408	-.8337
Hired labor..............	---	-.2499	---	---	---	---
Permanent labor..........	---	---	---	.3718*	---	.4838*
Casual labor.............	---	---	---	-.7389*	.7863	---

1/ Sources: Tables 5.1, 5.2, and 5.5.
2/ The asterisk identifies those elasticities derived from regression coefficients which were statistically significant at the 0.10 level or more.

the empirical evidence suggests that increased expenditures for irrigation do not significantly influence the amount of family labor employed.

Since data for irrigation expenses were not available for Thanjavur farms, this variable was deleted from the regression analyses in Thanjavur. While no empirical conclusions are available for Thanjavur, some insights can be gained. Improved water management in Thanjavur is not simply a matter of increasing the amount of irrigation water used by farmers. Farmers served by the public irrigation system are fairly certain that they will receive water. But they do not know how much they will receive, when they will receive it, or when they will be able to drain excess water from their fields. Better distribution of water throughout the production year may do more to increase production intensity, and thereby improve employment opportunities, than can be achieved by increasing the total quantity of water used.

Farm Machinery

Increased use of farm implements was hypothesized to be positively related to the amount of labor employed per farm. The regression analyses suggest that farm employment is not markedly influenced by variations in machinery investment. While the employment elasticities with respect to farm machinery were either statistically nonsignificant or small in size, the elasticities were positive in sign. Consequently, increased use of farm implements, when measured in terms of investment, did not have a substantial effect on farm employment.

The relatively small relationship between investment in farm implements and employment may be related to two factors. First, with the exception of the few farms in Ferozepur which owned tractors, the implements included in this variable are used by virtually all farmers and have been for many years. Second, investment in farm implements is a measure of capital stock, but it may not be an adequate measure of the flow of services obtained from these implements. Employment, while not related to the stock of farm implements, may be related to the flow of services derived from their use. Consequently, the relationship between employment and the use of farm implements may be more accurately measured with a variable which measures the flow of services from these implements rather than the stock of farm implements.

Bullock Labor

Bullock labor was hypothesized as being positively related to farm employment. Bullock labor was a highly significant determinant of the amount of family and hired labor employed. The significant and positive employment elasticities with respect to bullock labor tend to support the initially hypothesized relationship described above.

Bullock labor, however, like human labor, is a source of farm energy. An increase in the number of operations requiring bullock labor stems from a prior decision to increase the level of farm production by using greater quantities of high-yield seed and fertilizer, and improved farm management practices. Consequently, while increased employment of bullock labor is positively related to employment, the decision to increase the level of production activity seems to be a more fundamental generator of farm employment opportunities.

Seed-Fertilizer

Increased use of improved seeds and fertilizer was hypothesized as increasing the demand for labor. The regression results show that seed-fertilizer was a highly significant determinant of total farm employment in both districts. Hired labor, in particular, was positively related to increased expenditures for seed-fertilizer. Increases in seed-fertilizer expenditures had a greater effect on total and hired employment in Thanjavur (the labor-dense, rice-growing district) than in Ferozepur (the relatively labor-scarce, wheat-growing district). The results of the regression analysis, therefore, support the hypothesized relationship between seed-fertilizer expenditures and farm employment.

The green revolution may be characterized as a seed-fertilizer revolution (41, p. 569). Consequently, the significant and positive relationship between seed-fertilizer and farm employment is one of the most important findings of this study.

Percent HYV

Percent HYV was hypothesized to be positively related to farm employment. The regression results, however, consistently failed to detect any significant relationship between farm employment and percent HYV. Consequently, the statistical results do not support the initial hypothesis. This is perhaps due to the fact that percent HYV is season and crop specific. The high-yield variety for each district is a single crop which is produced on only a portion of the land cultivated in the season in which it is grown. Hence, percent HYV, while perhaps an index of adoption of modern farm practices, may not be an explanatory variable for the amount of labor employed over the entire farm business. 44/

Wage Rates

Economic theory suggests that the price elasticity of demand for a production input is negative. The estimated price elasticities of demand for the respective kinds of hired labor (permanent labor in Thanjavur excepted) support the above hypothesis.

While negative in sign, only for casual labor in Ferozepur was the employment elasticity with respect to the price of labor a significant determinant of the quantity of hired labor employed. The significant relationship between the wage farmers must pay casual laborers and the quantity of casual labor employed corresponds with recent increases in the wage paid for casual labor services in Ferozepur. With the supply of tractors and other harvest implements increasing and the price of casual labor increasing also, the price of capital in Ferozepur is declining relative to the price of casual labor. Consequently, Ferozepur farmers have an incentive to substitute harvest implements for casual labor.

Wages paid permanent labor in Ferozepur or casual labor in Thanjavur were not statistically significant determinants of the quantity employed of these kinds of labor. Consequently, increases in the wage paid to these kinds of labor are not apt to induce farmers to adopt substitute forms of farm energy.

As mentioned earlier, the positive price elasticity for permanent labor in Thanjavur seems related to the market for Pannaiyal labor in Thanjavur. This market institution, however, is diminishing in importance as a mechanism for allocating hired labor in Thanjavur. Consequently, the observed price elasticity for Pannaiyal labor, while interesting, is not particularly meaningful for policy purposes.

Substitution Variables

Hired labor may be used to supplement and/or substitute for family labor. A negative substitution elasticity between the respective kinds of labor is evidence that the substitution effect is of sufficient magnitude to countervail any possible supplementary relationship between them. Given that these contrasting employment effects may occur simultaneously, there was no a priori basis for choosing among the two alternatives.

The regression results were inconclusive in determining the magnitude and direction of the substitution relation between family and hired labor and between the two kinds of hired labor. Consequently, no conclusion can be made with respect to the net substitution relation between the respective kinds of farm labor.

CHAPTER 7. IMPLICATIONS OF AGRICULTURAL TECHNOLOGIES FOR FARM EMPLOYMENT IN INDIA

This chapter relates the preceding analyses and evidence from related studies to four aspects of the employment problem in India. The first three focus on the relation between farm production and farm employment, the distribution of employment among family and hired labor, and the relationship between farm mechanization and farm employment. Finally, the results of the microanalysis reported in the previous chapters are related to the prospects for increasing income and employment opportunities throughout the farm sector.

Production and Employment

The regression analysis shows that farms which increase their use of production inputs also tend to substantially increase the amount of labor (hired labor in particular) employed per farm. Of particular importance are inputs such as irrigation and seed-fertilizer. Consequently, policies which tend to increase production through the increased use of these or similar kinds of farm capital contribute to increases in farm employment opportunities.

Substantial increases in farm production have occurred in irrigated areas where the high-yield wheat and rice varieties could be rapidly adopted. That most of the increase in farm production has occurred in irrigated wheat- and rice-producing regions is due largely to the heavy emphasis on developing fertilizer-responsive varieties for these crops relative to other crops. 45/ In rainfed areas, farm production and farm employment opportunities have not increased as much as in the irrigated wheat- and rice-producing areas. High-yield varieties of other irrigated crops and of crops grown under rainfed conditions are only now being developed.

Nevertheless, the green revolution has shown how agricultural development is enhanced through technological change. While the superior food production technologies are not applicable to large areas in India where crops are grown under rainfed conditions, higher yielding varieties of crops suitable for these areas may have a substantial effect on farm production and employment.

To develop varieties of rainfed crops which have higher yield potentials will require investments in agronomic research similar to that which occurred in wheat and rice. Since the amount of genetic research on rainfed crops has been modest, substantial investments of time and money will be required to achieve the mass of knowledge prerequisite to the development of high-yield rainfed crops. Further, new varieties will still have a high degree of drought resistance. This resistance to environmental variations generally comes at the expense of yields. Consequently, the proportional increases in yields from rainfed crops may be lower than those obtained from high-yielding irrigated crops.

Increased employment opportunities in Indian agriculture ultimately depend on the rate of increase in farm production. Consequently, measures which encourage increased farm production enhance the growth of farm employment opportunities. Genetic research on irrigated and rainfed crops is important among the group of production-increasing measures which are available. Other services and incentives (such as production credit, favorable input prices, adequate supplies of inputs, and efficient product markets, among others) also contribute significantly to increases in farm production and employment.

Many measures designed to redistribute income or employment among the farm labor force have been offered as a means of improving income and employment opportunities in Indian agriculture. One of these, the Crash Scheme for Rural Employment, proposes that the Government of India employ up to 1,000 laborers per district in various kinds of labor-intensive public works projects. These programs offer immediate increased employment opportunities to a modest portion of the landless agricultural laborers. Also, such schemes may have a long-run effect on production and employment if they result in the manufacture of production-enhancing infrastructure such as village roads and water conservation reservoirs. As such, public works schemes are an important element in a package of policies to increase rural employment. Public works programs, however, do not substitute for programs which increase rather than redistribute income and employment opportunities.

Distribution of Employment Benefits

The existence of underutilized or surplus labor capacity within the farm family unit is a widely discussed aspect of the income-employment problems in Indian agriculture (4, 50, 65, 72). Excess labor capacity within the family unit implies that increased quantities of family labor may be forthcoming in response to increases in production opportunities on the farm. Increased land use intensity stemming from the increased use of modern production techniques and inputs therefore might be expected to have a relatively larger effect on the employment of family labor than on hired labor. If this is the case, the largest increases in employment opportunities will be with farm operators and their families rather than hired labor.

To the degree that this occurs, agricultural development will fail to afford increased employment opportunities for landless and semilandless laborers. One consequence may be the accelerated migration of unemployed farm laborers to urban centers where employment opportunities and public services are already overtaxed.

Hired labor, however, is the beneficiary of much of the increase in farm employment resulting from more intensive cultivation, according to the regression analyses. The employment elasticities for family labor varied with respect to the quantity of various production inputs employed per farm. Further, of the two kinds of hired labor, variations in the use of production inputs per farm tended to have a greater effect on the employment of casual labor than on permanent labor.

Employment of Surplus Family Labor

The apparently insignificant employment effects on family labor appear to be related to inelasticities in the supply of family labor. Further, the excess labor capacity within the family unit may be smaller than presumed. Two interpretations with respect to the existence of excess family labor capacity are possible.

The first interpretation is that observed periods of idleness on the part of family members may overestimate the potential supply of family labor actually available. The potential supply of family labor is usually defined as the difference between some normative number of days, say 300, defined as a full employment year, and the number of days family members were actually employed. That family labor is occupied for a shorter period than a "full employment year" does not necessarily imply that family labor per farm will significantly increase as land use intensity increases.

The second interpretation is that farms sampled in Ferozepur and Thanjavur did not contain large quantities of underemployed family labor. If there is little excess labor capacity within the family unit, then the farm family cannot supply additional labor in response to increases in the demand for farm energy. This may be particularly true if the demand for farm energy increases primarily in seasons when family labor is already almost fully employed.

The results of the family labor analysis do not permit one to choose among these two explanations. Nevertheless, the results do suggest that family labor per farm does not vary freely with variations in the use of farm inputs. Among the factors which influence the quantity of family labor actually supplied are (1) family size, (3) the opportunity cost of employment in the farm enterprise, and (3) caste.

Farm Mechanization and Farm Employment

Farmers in the developing parts of India are purchasing tractors and other laborsaving implements in conjunction with the increased use of other farm inputs. The introduction of laborsaving equipment on farms in a country which is generally described as containing surplus labor has fostered wide controversy. Some contend that tractor mechanization can considerably enhance agricultural productivity in countries where high-yielding varieties are being widely adopted (22; 14, p. 225). Others believe that the social costs of tractor mechanization, measured in terms of rural unemployment, will be too great (41, pp. 569-582).

Tractors

The relationship between farm tractors and employment of farm labor was examined only on farms in Ferozepur, since no farmers in Thanjavur used tractors.

Several forms of regression tests were performed to identify the effect of the use of tractors on farm employment (78, p. 150). These tests failed to detect any statistically significant relationship between the use of farm tractors and the quantity of hired labor employed. The lack of statistical association is probably related to the fact that only 23 of the 150 farms examined in Ferozepur owned a farm tractor.

A tabular analysis, however, shows that farms which used tractors tended to employ an equal or greater amount of hired labor than farms of comparable size not using farm tractors. Included in this analysis are farms in the three groups containing the largest farms. Only two farms in class 3 and four farms in group 4 owned tractors. More than half (17 of 30) of the farms in size class 5 owned tractors, however. Hence, while the tabular analyses include comparisons for farms in all size classes, the weight of the analysis rests primarily on farms in class 5.

Farms in class 5 (the largest farms) which owned tractors employed more hired labor than the other farms in that class (table 7.1). Further, expenditures for hired labor services were about the same percentage of total production expenses on the farms with tractors as on farms of comparable size without tractors (table 7.2).

Tractors, however, substitute directly for bullock labor. Farms with tractors in size class 5 used only half as much bullock labor as the other farms in the class (table 7.1).

Farms which owned tractors also exhibited other attributes which distinguished them from farms which did not. Farms which owned tractors spent more for seed-fertilizer and employed more hired labor per hectare, and, partially as a consequence, obtained a greater value of output per hectare and per man-day of hired labor (table 7.3). This implies that, relative to farms now owning tractors, the employment opportunities as well as hired labor productivity on tractor-owning farms were greater. Further, a higher proportion of those farms which owned tractors also owned a tubewell or pumpset than farms now owning a large tractor (table 7.4).

This suggests that tractors may be a requisite input for intensive cultivation on large farms in Punjab. The increased intensity of land use which is possible with tractors affords an opportunity to employ increased quantities of hired labor in other tasks. These positive employment effects seem to be only partially offset by direct substitution effects for hired labor in those operations where tractors substantially reduce the amount of labor required for a particular operation.

Sources of Increased Production and Employment Intensity

Increased resource use and production intensity on farms with tractors stems from a tendency for those farms to crop more intensively among as well as within seasons. Production intensity among seasons is reflected in the number of crops grown per calendar year. This is reflected in a multiple-

Table 7.1--Employment of family and hired labor and bullock labor per sample farm, and hired labor and bullock labor per hectare, farms with and without tractors by size class of farm, Ferozepur, 1967/68

Size class	Mean size	Labor employed per farm: Family (1)	Labor employed per farm: Hired (2)	Labor employed per farm: Total (3)	Hired labor per hectare (4)	Bullock labor: Per farm (5)	Bullock labor: Per hectare (6)
	Ha.	Days					
Without tractors:							
3	10.9	396.3	491.7	887.9	44.9	240.3	22.0
4	15.9	427.5	702.7	1,130.2	44.1	284.5	17.9
5	23.6	468.6	767.5	1,236.1	32.5	407.0	16.7
With tractors:							
3	11.1	495.0	602.5	1,097.5	54.1	274.1	24.7
4	15.3	349.4	607.3	956.8	39.6	144.2	9.4
5	24.5	441.8	1,031.1	1,472.8	42.1	206.0	8.4

Table 7.2--Expenditures for hired labor as a percentage of total production expenses per farm, farms with and without tractors by size class of farm, Ferozepur, 1967/68

Item	Size class: 1	2	3	4	5
	Percent				
Farms without tractors	1/ 16	25	26	27	29
Farms with tractors	2/ --	--	22	27	29

1/ The coefficients were obtained by dividing the sum of expenditures for permanent and casual labor by the sum of all actual production expenditures incurred in cash and kind, including expenditures for hired human labor, bullock labor, seed, manure, fertilizer, implement charges, land taxes, irrigation fees, rent actually paid, and miscellaneous charges.

2/ No farms in size classes 1 or 2 owned tractors.

Table 7.3--Value of output per hectare and per man-day of hired labor, and expenditures for seed and fertilizer per hectare on farms with and without tractors by size class of farm, Ferozepur, 1967/68

Size class	Mean size	Value of output per hectare (1)	Value of output per man-day of hired labor (2)	Expenditures for seed and fertilizer per hectare
	Hectares		Rupees	
Without tractors:				
3	10.9	1,750.1	38.9	131.6
4	15.9	1,649.5	37.4	142.5
5	23.6	1,588.7	48.9	127.2
With tractors:				
3	11.1	2,599.2	47.3	181.1
4	15.3	1,786.9	45.0	187.4
5	24.4	2,130.8	50.5	181.7

Table 7.4--Percentage of farms with and without tractors which own tubewells or pumpsets by size class of farm, Ferozepur, 1967/68

Item	Size class				
	1	2	3	4	5
Farms without tractors	33	26	39	38	15
Farms with tractors	1/ --	--	50	75	76

1/ No farms in size classes 1 and 2 owned tractors.

cropping ratio which measures the number of crops grown per year. Within a given crop season, greater production intensity results from an increase in resource use per hectare actually cultivated--i.e., adjusted for multiple-cropping. 46/

Farms with tractors tended to multiple-crop a higher portion of their land than farms not owning tractors (table 7.5). This was reflected in the multiple-cropping ratio, which was larger on farms with tractors than on farms without tractors. Tractors were a contributing input which enabled farm operators to increase the size of operation by increasing the area cultivated.

Farms with tractors also employed more resources and obtained a higher value of output per hectare of land actually cultivated than farms not owning tractors (table 7.5). Only farms in group 5 with tractors employed more hired labor per hectare actually cultivated than farms not owning tractors.

Two aspects of this analysis need emphasis. First, tractors were used in concert with other inputs to intensify land use per farm both within and among seasons. Second, large farms with tractors tended to employ more hired labor per hectare than farms not owning tractors. If tractorized farms had used bullock labor instead of tractors, but produced with the same level of intensity, perhaps even more hired labor per hectare may have been required. But whether the same level of land use intensity could have been achieved on these farms is uncertain, in light of the importance of timeliness of operations in multiple-cropping systems.

Other Implements

In addition to tractors, farmers in northwest India are rapidly adopting reapers and threshers to permit more timely harvesting of the Rabi wheat crop. 47/ The introduction of these implements on a widespread basis may have a more profound effect on employment of casual labor than the introduction of tractors.

While tractors do not substitute directly for hired labor, threshers and reapers are quite different. Traditionally, the wheat crop is cut, piled, bundled, and piled again by hand labor. Bullock carts transport the sheaves of wheat to the threshing site. Bullock- or tractor-drawn reapers mechanize the cutting and piling operation. A reaper-binder also mechanizes the bundling operation. These implements, therefore, substitute for harvest labor.

A thresher substitutes for both bullock and human labor. Traditionally, the harvested wheat is separated from the straw in two operations. First, bullocks walk over the wheat and straw to loosen the grain in the heads. The loosened wheat heads are poured slowly from small baskets on a windy day. The chaff is blown by the wind while the heavier wheat kernels fall straight to the ground. This is a labor-intensive means of threshing. A machine thresher considerably reduces the amount of human labor required for this task. 48/ Also, since the farmer is no longer dependent on wind, he can thresh the crop in a shorter time and reduce the risks of a premonsoon shower spoiling the crop.

Table 7.5--Multiple-cropping ratio, value of output, expenditures for seed and fertilizer, and hired labor per hectare, each adjusted for multiple-cropping, farms with and without tractors by size class of farm, Ferozepur, 1967/68 1/

Size class	Multiple-cropping ratio 2/ (1)	Adjusted value of output per hectare 1/ (2)	Adjusted expenditures for seed and fertilizer per hectare (3)	Adjusted hired labor per hectare (4)
	Percent	--------- Rupees	-----------	Days
Without tractors:				
3	1.37	1,277.5	100.1	32.8
4	1.30	1,268.7	109.6	33.8
5	1.20	1,323.7	106.0	27.0
With tractors:				
3	1.66	1,542.6	109.1	32.5
4	1.35	1,323.7	138.8	29.3
5	1.27	1,677.3	143.1	33.1

1/ The adjusted coefficients in columns (2), (3), and (4) reflect the value of output and expenditures for seed and fertilizer per hectare actually cultivated. They are derived by dividing the coefficients in columns (1) and (3) in table 7.3 and column (4) in table 7.1 by the multiple-cropping ratio in column (1) of table 7.5.

2/ The multiple-cropping ratio measures the average number of times per year that land is used to produce a crop. A ratio of 1.0 indicates that all land was sown to crops one time per year. An index of 1.5 indicates that all land was used once and half of the land was also sown to a second crop.

Seasonal variations in the price of casual labor (table 7.6) also encourage farmers to purchase machines which substitute for harvest labor. Casual laborers are in short supply relative to demand during harvest season in Punjab. Farmers in some areas in April and May 1970 reportedly waited several weeks to obtain casual labor to harvest their crop. Under these circumstances, farmers logically seek means to circumvent harvest labor bottlenecks. However, since these implements apply to specific harvesting operations it seems unlikely that the use of them will have a significant direct impact on employment in other seasons.

Table 7.6--Average wage paid casual field workers in Punjab by quarter, 1968/69

July-September	October-December	January-March	April-June
Rs. per day			
5.06	4.99	4.86	5.91

Source: Averages calculated from unpublished data collected by Economic and Statistical Advisor to Punjab, Government of Punjab, Chandigahr.

Mechanization of farm operations in Punjab may also be occurring as a consequence of a general shortage of hired labor. Punjab is highly industrialized relative to other States in India. With only 54 percent of the labor force in the State engaged in agricultural production, there are substantial opportunities for employment in other industries. High wages paid farm labor relative to other States in India are evidence of an active market for nonfarm labor (19, p. 43). Consequently, relative to most other areas in India, mechanization of farm operations in Punjab may be occurring as a result of a relatively active and healthy labor market in both the farm and nonfarm sectors.

This analysis, while limited to a cross section of farms in Punjab, suggests some factors to consider in developing a mechanization policy with respect to the country as a whole.

Mechanization Policy

Large farm tractors and harvest implements are being adopted rapidly in Punjab, for three reasons: (1) The supply of farm machinery is increasing, (2) the machines permit farmers to achieve greater production intensity, and (3) the price of labor, especially harvest labor, is rising.

The use of tractors on large farms in Punjab does not appear to have reduced the demand for hired farm labor. Nevertheless, few persons feel they can safely predict the longer run consequences of tractor adoption on farm employment. Part of the quandary stems from uncertainty about the employment effect of the use of tractors on small farms. The use of tractor services may permit smaller farmers to reduce the total amount of labor hired. Also, it is not clear whether such labor substitution would be offset by an increased demand for labor caused by more intensive farming (as appears to be the case on large Punjab farms). Other major determinants of the aggregate effect of tractors on farm employment include changes in the supply of hired labor, changes in the demand for farm energy, and the supply and conditions of supply of tractor services.

The Supply of Tractors and Other Implements

There are apt to be wide interregional differences in the supply of tractors. In areas like Thanjavur, where farms are small, hired labor is more abundant, and wages paid hired labor are lower relative to areas like Ferozepur, only a small portion of the farms are likely to purchase tractors. Further, rice, which is produced in small paddies, requires more labor than wheat and does not offer the economies of size which make tractors well suited to large farms in wheat-producing regions. Also, tractors require fuel, parts, and maintenance services, all of which may be scarce in areas where only few farmers use tractors. For this reason, farmers in those areas will tend not to purchase additional tractors, and tractor populations will remain concentrated in areas where maintenance is more readily available. Likewise, the influence of tractors on production and employment will also be greater in some areas than in others.

The availability of custom tractor services to individuals with farms too small to justify the purchase of a tractor is also important. Less than 20 percent of the Punjab farms have sufficient size to afford the purchase of a large tractor (20-40 horsepower). In most other States, the proportion of farms which have farms large enough to justify outright tractor purchase is much smaller. Since only a small portion of the farm population is likely to own a large tractor, the supply of tractors potentially available for custom farmwork will also be small. 49/ Also, farmers who own large tractors supply custom services only after the crop needs on their own farm have been met. This will also tend to limit the supply of custom tractor services.

Machinery services also can be made available to small farms by reducing the size of the farm implement. Small tractors (two-wheel garden tractors) are not widely used in India. Hence, their influence on farm employment has been small.

Reapers and other harvest implements are more widely adoptable. These implements are cheap and substitute directly for harvest labor. As yet, there is insufficient evidence to tell whether these implements will cause a net reduction in harvest employment opportunities when evaluated in light of the production and employment expansion effect. Nevertheless, it appears that a comprehensive policy with respect to mechanization must distinguish between the different kinds of implements which are available to farmers. Some implements have a strong labor displacement effect while others may not.

The Demand for Tractor Services

The evidence from Ferozepur suggests that increases in the price of labor relative to capital afford economic incentives to farmers to purchase farm implements. This has a double meaning. First, in areas where the price of labor increases relative to capital, farm mechanization may be occurring in response to labor shortages. Shortages frequently are the result of a relatively healthy market for hired labor. Under these conditions, the use of laborsaving implements may not generate serious unemployment problems. On the other hand, if the price of labor increases relative to capital through artificial restrictions on the supply of labor (such as labor unions) or subsidies on farm implements, the adoption of farm implements may have serious effects on farm employment opportunities. Artificial distortions in relative factor prices may encourage farmers to adopt laborsaving implements which otherwise would not be profitable. Consequently, public subsidies on tractors tend to reduce the price of tractors relative to labor and increase the quantity demanded.

In the last few years, India has imported a large portion of the tractors purchased by farmers. These tractors have been imported at overvalued exchange rates which make them less expensive than domestically manufactured tractors would be. It is questionable, however, whether these lower prices are passed on to the farmer. A very active black market in tractors probably has done much to offset the potential implicit tractor subsidy to the farmer. Regardless, policies which tend to distort factor price ratios must be closely examined for possible farm employment tradeoffs which may result. In addition to possible losses of farm employment opportunities, the social costs of mechanization may include the expenditure of scarce foreign exchange, farm consolidation which displaces small farm operators, and other factors.

Conclusions

The mechanization of certain farm operations appears to be occurring in response to changes in the demand for farm energy relative the supply of labor. Tractors and other implements seem to be contributing to increased farm production. Nevertheless, the long-run effect of farm mechanization on farm employment opportunities is by no means clear. Some implements may increase employment opportunities for farm labor while others do not. Rules of thumb which presume that machines displace labor or create additional employment are not likely to offer much guidance in formulating policy. In deciding whether the use of a given implement is to be encouraged or discouraged, consideration should be given to the economic stimuli which make that machine profitable to the individual farm operator. Then, with this information in hand, the social and private costs and returns associated with the machine's use can be compared and a policy decision formulated.

Aggregate Farm Labor Absorption

The results of this study strongly suggest that increased intensity of farm production, through increased use of biological capital, has a strong positive influence on farm employment opportunities. Recommendations were made in preceding sections of this chapter with respect to policies to accelerate farmers' adoption of intensive farming practices as a means of increasing farm employment opportunities. However, even with the implementation of such policies, the rate of growth in India's farm sector may not be large enough to achieve rapid increases in aggregate farm employment opportunities or substantial improvements in per capita incomes for India's hired labor force. This section extends the implications of the preceding microeconomic analysis to the entire farm sector by theoretically examining those factors which determine the aggregate-labor-absorptive capacity of a developing agricultural sector.

From the standpoint of the total economy, the rate of increase in farm employment depends on three factors: (1) The rate of increase in real farm production, (2) the rate of increase in aggregate demand for farm products, and (3) changes in farm labor's share of total income. Of the three, a relatively slow rate of growth in aggregate demand for farm products seems to present the most serious constraint to achieving rapid increases in employment opportunities in Indian agriculture.

Increase in Aggregate Demand

The price elasticity of demand for farm products in general and food grains in particular is less than unity. 50/ Consequently, any increase in the quantity of farm products supplied which exceeds the rate of increase in aggregate demand will be subject to a decrease in farm product prices. The result will be an increase in total revenue to agriculture which is proportionally smaller than the increase in physical output.

The demand for production resources within an industry ultimately depends on the demand for the final product of that industry. The rate of increase in the demand for labor, a major input in farm production, therefore, depends on the rate of increase in the demand for the products produced by labor. This, of course, assumes that production can be elicited from the farm sector which is equal to or greater than the rate of increase in aggregate demand. This assumption is at odds with India's farm production record from 1920 to 1965. However, the substantial investments in agriculture coupled with the new production technologies now in use and being developed suggest that the assumption may be valid.

The degree of decline in the terms of trade which can be absorbed by the farm sector before the rate of absorption of farm inputs also begins to decrease is unclear. Among other factors, this depends on the annual shift in the aggregate supply function for agriculture, which is in turn dependent on changes in resource efficiencies and the supply of farm inputs.

These complicating factors notwithstanding, the rate of increase in aggregate demand for farm products is an important factor determining the rate of increase in the demand for farm labor. The rate of increase in aggregate demand for farm products depends on (1) the initial supply of farm products relative to demand, (2) the rate of increase in aggregate domestic demand for farm products, and (3) the export demand for farm products. Taking these aspects into consideration, the rate of increase in income to all factors of farm production in India is likely to be about 3.5 percent per year over, say, the next ten years. The annual rate of increase in income and employment in agriculture will be slightly greater or less than 3.5 percent, depending on whether its share of income increases or decreases.

In the mid-1960's, aggregate demand for farm products substantially exceeded the supply. Even in 1970/71, the supply of food grains (approximately 108 million metric tons) was 3.7 percent less than the estimated demand for food grains (111-112 million metric tons). A portion of this deficit has been offset through commercial and concessional food grain imports. Because of the initial shortage of food grains relative to demand and the need to develop a price stabilizing grainery reserve, domestic food grain production can, over the short run, increase more rapidly than the annual increment in domestic demand for farm products without resulting in a decline in farm prices.

The annual rate of growth in aggregate domestic demand is the most important factor (on the demand side) in determining the rate of increase in income to all factors of production--and by that token income and employment to farm labor. Aggregate domestic demand is likely to increase by 3 to 4 percent per year. The rate of increase in aggregate domestic demand for food can be expressed as $D = p + n_i . g$, where D is the percent increase in demand for food, p is the rate of population growth, n_i is the income elasticity of demand, and g is the rate of increase in per capita income. In India, assume that $p = 2.3$ percent, $n_i = 0.50$, and $g = 1.6$ percent (16, pp. 1,8; 55, p. 80). Inserting these into the above equation, D is estimated as 3.10 percent.

Aggregate demand for farm products can also be increased by increasing exports of farm products. India's fourth 5-year plan, for example, emphasizes the need to increase exports of farm products--marine products, leather and leather products, fresh fruit, and vegetable oils. The plan projects an annual increase in farm product exports of 6.5 percent from 1968/69 to 1980/81. Farm exports, however, are less than 6.0 percent of the total value of farm products. Hence, the export promotion targets for agriculture, while admirable and probably feasible, will result in only a 0.39-percent annual increment in aggregate demand for farm products (6.0 x 6.5 = 0.39). A 0.39-percent increase in farm exports coupled with a 3.10-percent annual increment in domestic demand for farm products implies a total increment in aggregate demand for farm products of 3.49 percent per year.

Changes in Labor's Income Share and Aggregate Labor Absorption in Agriculture

The rate of increase in farm resource use depends on the rate of increase in farm production, which in turn is constrained by the rate of increase in aggregate demand. If production inputs--land, labor, and capital--are valued on the basis of their marginal contribution to total revenue accruing to agriculture, then the total value of farm production equals the sum of the value of inputs used in production. The rate of increase in income paid to a particular input, labor, therefore depends on (1) the rate of increase in total farm production, (2) changes in the income share paid to farm labor, and (3) changes in the supply of farm labor relative to the supply of labor substitutes.

If one assumes that total farm production increases at the same rate as the annual increase in demand for farm products, say 3.5 percent, then the rate of increase in income paid to a particular input depends on the change in the share of total agricultural income paid to that input. 51/ If the share of income to labor increases or remains constant over time, then the amount of income paid to labor will increase more rapidly or at the same rate as the increase in total revenue. If the share of income paid farm labor declines, then the amount of income paid to labor will increase at a lower rate or may even decrease relative to total farm income. 52/

Whether the income share which accrues to farm labor increases, remains constant, or declines, depends on the stage of development of a particular country, the price of labor relative to other inputs, and other aspects. Since 1949, the share of farm income paid to farm labor in the United States decreased from 35 to about 20 percent (45, p. 413). In Taiwan, the share of income paid to farm labor remained constant at about 25 percent from 1911 to 1965 (8, p. 18). In India, the share of total farm income paid to farm labor has remained at about 34 percent since 1950 (46, p. 45). Given India's stage of economic development and the increased use of farm capital, which at the moment is essentially land rather than labor saving, the share of total farm income paid to labor in agriculture is likely to remain essentially unchanged. For this analysis, it is assumed that the share of farm income paid to farm labor will remain constant over the next decade or two.

With a 3.5-percent annual increase in farm production and no change in the share of total farm income paid to labor, total income to farm labor will also increase by 3.5 percent. But with the farm labor force increasing by 2.3 percent per year the per capita increase in income to farm labor will be 1.2 percent. Since the total wage bill for farm labor is the product of the unit wage times the quantity of labor employed, one cannot tell whether the increase in aggregate income will consist of an increase in unit wages or employment. However, if one assumes that the unit wage does not increase substantially, then most of the increase in farm labor income will occur as a result of an increase in farm employment. 53/ Less rigid assumptions which assume some increase in labor wage rates suggest that per capita income in agriculture may increase by less than 1.2 percent per year.

This preliminary analysis only establishes the general direction and magnitude of change in farm employment opportunities over the next decade. Further, analysis, which examines alternative rates of increases in farm production, changes in farm wages, and different rates of growth of exports and domestic demand for farm products, would afford more precise guidelines on the labor-absorptive capacity of Indian agriculture. This research would have substantial payoff in formulating an employment policy. However, the present analysis suggests several areas of action to increase per capita employment opportunities in agriculture.

Population

To the extent that population continues to increase, the number of persons for whom additional jobs must be created will increase geometrically. The labor force for the next 15 to 20 years has already been born. Reductions in the absolute increase in labor supply depend on efforts to control the rate of population growth. Consequently, the contribution of population control measures in reducing unemployment will not be apparent for about two decades. Nevertheless, a reduction in the rate of population growth is fundamental to solving the employment problem, and such programs must be vigorously pursued now.

Dryland Farming

The rate of increase in farm production is likely to vary among regions. Consequently, in rapidly developing regions, per capita farm employment opportunities may increase substantially more than the national average. In less rapidly developing areas, the per capita change in farm employment opportunities may be zero or even negative. The aggregate analysis, therefore, underscores the need for emphasis on increasing farm production opportunities in areas and crops which have not yet been influenced by the new food grain technologies. An increase in farm production opportunities is fundamental to increasing farm employment opportunities in these regions.

Aggregate Demand: Exports and Diversification

Measures which increase the rate of growth in aggregate demand for farm production will enhance the opportunities of increasing farm production and farm employment. These measures can focus on both domestic markets for farm products and the export market.

The rate of increase in domestic demand for farm products is determined by (1) the income elasticity of demand for farm products, (2) the rate of increase in population, and (3) the rate of increase in per capita income. For the domestic market, measures which encourage farmers to diversify production to include products for which the income elasticity of demand is high should be considered. Other opportunities for increasing the rate of increase in domestic demand for individual farm products are limited.

Particular attention should be paid to the promotion of farm exports. Historically, countries which have experienced rapid rates of agricultural development have been supported by exports of farm products to other countries. In India, however, only about 6 percent of the total value of farm production is exported. Consequently, relatively large increases in farm exports will be required to have any appreciable effect on aggregate demand for farm products. For example, a 20-percent annual increase in exports of farm products (assuming farm exports to be 6 percent of the total value of farm products) is required to increase aggregate demand for farm products by about 1.2 percent.

Further, there are many countries wishing to increase foreign sales of farm products. Several countries, including the United States, Japan, and Thailand, are already marketing wheat and rice on concessional terms. India's focus on marine products, fruit, leather, etc., represents a concentration on the kind of specialized products for which there may be considerable market opportunities.

Traditionally, farm exports have been considered as a means of earning foreign exchange. Farm exports, however, can also contribute in a significant way to agricultural development and increased employment opportunities in agriculture. Consequently, particular attention should be focused on increasing farm exports throughout the entire range of farm commodities for which export markets may exist.

Nonfarm Employment

The aggregate analysis suggests agricultural development offers only a partial solution to the Indian unemployment problem. In addition to efforts to reduce the rate of population growth and to increase farm employment opportunities, measures which increase the rate of growth of nonagricultural and agribusiness industries must be an integral part of a national program to increase employment opportunities in the country.

Agricultural development, as a consequence of increased flows of farm output through commercial markets, and an increased demand for purchased farm inputs, stimulates the growth of agribusiness firms. In regions where agricultural development is occurring, opportunities for rural nonfarm employment may arise to afford employment opportunities for the rural labor force.

In areas like Punjab, for example, where substantial agricultural and nonagricultural development has occurred, the possibility of expanding rural nonfarm employment opportunities should not be overlooked. About 77 percent of the population of Punjab are rural residents. Yet, of those employed in the State, only 56 percent are engaged in farm production (61). Many rural residents, therefore, are engaged in nonfarm manufacturing and service industries. Further, an increase in primary production and exports has been linked to an increase in manufacturing employment in industries producing inputs for primary production, industries processing primary products, and industries producing products to satisfy increases in final demand (8, 29).

While little is known about the relationship between agricultural development and farm-nonfarm employment linkages, these linkages may be important. Given the magnitude of the employment problem in rural India and the related problem of large rural-urban migrations, the need to create increased employment opportunities within the rural sector is great. Clearly, more information is needed with respect to these linkages if an effective national policy to maximize employment opportunities is to emerge.

FOOTNOTES

1/ Underscored numbers in parentheses refer to Literature Cited, p. 83.

2/ Unpublished estimates, U.S. Agency for International Development, New Delhi, 1969.

3/ For prestige reasons they usually identify themselves to census enumerators as cultivators.

4/ The analysis based on table 1.2 is adapted from (68).

5/ "Between 1950 and 1964 employment in the large scale manufacturing sector increased at an annual rate of about 6 percent or a little better while the real value added by this sector rose at an annual rate of over 10 percent. During the same period capital stock in constant prices rose at an annual rate of about 17 percent per year. Thus the growth of employment lagged behind the growth of value added and capital stock. Two major forces are identified as being responsible for this rise in capital-labor ratio. The first relates to the developmental policies such as the bias in favor of basic and heavy industries and the import substitution policy, among others. The second is of course the changes in the price of capital relative to labor" (70, pp. 30-31). See Also (56, pp. 161-183; 73, pp. 256-257).

6/ Concomitant with the development of a "purchased-input-using agriculture," there also develops an agribusiness sector which supplies purchased inputs to farmers. The agribusiness sector may afford substantial opportunities for nonfarm employment within the rural sector.

7/ For a thorough discussion of various views of labor use relative to other factors in Indian agriculture, see (53, pp. 959-1092). Low farm wages, disguised unemployment, and underemployment in Indian agriculture have been explained as consequences of overutilization of labor relative to land, which is manifested in the form of low marginal and average products of labor (42, 44, 62). These explanations may be valid when only land and labor are considered as factors of production in developing agricultural economies. However, farmers adopting modern production practices also use greater quantities of purchased inputs--seed, fertilizer, and irrigation. Large absolute and relative increases in the use of capital on farms permit large absolute increases in the use of farm labor without increasing the amount of labor relative to the total quantity of farm inputs. This implies that adoption of modern farm practices enhances the capacity of agriculture in general to absorb labor. Likewise, in regions where modern farming practices cannot be widely adopted due to deficiencies in natural resources, the labor-absorptive capacity of agriculture is apt to be less than in areas more favorably endowed with respect to natural resources (78, p. 122).

8/ Data for 1967/68 are from table 1.2, column 2. Some of the increases in area cultivated resulted from reductions in the amount of land left in annual fallow, while some came from cultivating previously uncultivated land.

The size of the farm labor force during this time was also growing. The argument suggests that labor employed in agriculture relative to land, while not decreasing, probably did not increase greatly. See also (6, pp. 28-34).

9/ Wheat yields declined from 692 kilograms per hectare to 634, while rice yields decreased from 888 to 772. Similar long-term decreases in output per hectare occurred in most other crops as well (81, pp. 90-91). The decline in yields during this period was accompanied by an expansion in land area cultivated. Much of the expansion represented reclamation of wasteland. Between 1920 and 1950, reclamation of wasteland accounted for more than 75 percent of the increase in area cultivated. Cropping intensity, however, did not increase substantially. This is reflected above in the decline in food grain yields. Nor did farmers multiple-crop a greater portion of their land. The decline in yields, therefore, seems to be the consequence of the extension of traditional farming techniques to land of lower production potential. Investments of capital and labor, while increasing in absolute terms, probably did not increase per unit of land cultivated.

10/ Myrdal goes one step further and argues that "in spite of the very large labor force and often high man/land ratio...South Asian Agriculture is 'labor extensive' " (66, p. 1254). In a different context Dantwala argues that "...the very backwardness of agriculture is a favorable factor. There is so much scope for the wider application of known techniques, involving hardly any additional capital investment, that in the initial period, at any rate, progress can be rapid" (11, p. 5).

11/ About 30 percent of the farm labor force are landless laborers, and about 11 percent of the farm holdings are less than 1 acre.

12/ See (18, pp. 454-461; 7, pp. 895-899; and 26, p. 72).

13/ One can only observe price and quantity equilibrium points for a series of supply and demand relations. If the demand curve shifts over time (or space) with a stationary supply curve, the data plot out a supply curve, and vice versa. When both supply and demand curves shift, neither the supply nor the demand curve is distinguishable (84, pp. 217-235).

14/ For example, in an arithmetically linear function: $Y = a + b_1X_1 + b_2X_2 + \dots b_nX_n$, the regression coefficient, b_1, defines $\frac{\partial Y}{\partial X_1}$. Since $\frac{\partial Y}{\partial X_1}$ is given by b_1, then the employment elasticity, $\frac{\partial Y}{\partial X_1} \cdot \frac{X_1}{Y} = b_1 \cdot \frac{X_1}{Y}$.

15/ Irrigation eliminates the need for fallowing land during the rainy (Kharif) season to accumulate sufficient moisture to produce a crop during the dry (Rabi) season--a common practice on many of India's unirrigated farms. The use of inorganic fertilizers reduces the need for fallowing land to replenish the supply of plant nutrients in the soil.

16/ Paglin (57) observed that at least twice as much labor is employed per hectare on irrigated crops than on the same crops produced without irrigation. In addition, farms which have a large number of hectares irrigated tend to use more labor per hectare. Hence, irrigation and improvements in irrigation facilities seem to be necessary features for more intensive use of farm inputs and increased employment of farm labor. See also (48, 83, and 87).

17/ Reapers and threshers are now widely used on Ferozepur farms, but at the time data were collected these implements were not widely used. Possible employment effects related to farmers' adoption of these implements are discussed in chapter 7.

18/ Plowing with a team of bullocks and an improved moldboard plow requires 29.6 man-hours and 29.6 bullock team-hours per hectare cultivated. Plowing with a 25-horsepower tractor and a double moldboard plow eliminates bullock labor completely and require only 5.4 man-hours per hectare (71, pp. 55-56).

19/ Wheat is grown only in the Rabi season. The Rabi season begins in mid-October and continues through mid-April or May. Further, not all of the Rabi crop is sown to wheat. Hence, on farms in Ferozepur the area sown to high-yield wheat was measured as a percentage of the area sown to all wheat. Likewise, high-yield rice varieties are specific with respect to season. In Thanjavur, adoption of high-yield rice was measured as the percentage of the rice area sown in the Kuruvai season by the Intensive Agricultural District Program Office for farms in Thanjavur District. The Kuruvai season commences in June to July and continues through October to November.

20/ Family labor is a residual income claimant. That is, the return to family labor is that amount of money which remains after actual and imputed expenses have been deducted from gross returns to the farm business. Hence, the income per family member employed on the farm is a variable whose magnitude is determined ex post. Abstracting from this conceptual difficulty, the income residual accruing to farm family workers may be hypothesized as influencing both the supply of and demand for family labor.

On the supply side, as the opportunity cost (income foregone in other employments) of "on own farm" employment increases, the supply of family labor to the farm business will decline. By the same token, as the income residual from the farm enterprise increases, the supply of family labor will tend to increase.

On the demand side, a large income residual to the farm enterprise implies that the level of production activity on the farm enterprise is high. This high level of production activity, in turn implies that the demand for farm labor is also large. Family labor is one source of labor to the farm enterprise. Hence, the greater the income residual to the farm enterprise ceteris paribus, the greater the quantity of family labor demanded per farm.

21/ Most persons, however, continue to reside in rural areas. In Punjab, 77 percent of the population were rural residents; 79 percent of the population in Ferozepur was rural (61, pp. 17, 19, 113).

22/ About 73 percent of the people in Tamil Nadu are rural residents, and 80 percent of those in Thanjavur are rural residents (79, p. 13).

23/ The data record for one of the Thanjavur farms was incomplete and was, therefore, deleted. Consequently, the Thanjavur analysis is based on data from 149 farms.

24/ For additional details regarding the sample see (76).

25/ This level of adoption is noteworthy, particularly in light of the fact that high-yielding varieties of wheat were not commercially available prior to 1965/66 and were not widely available prior to 1966/67.

26/ One could interpret the 37-percent area adoption rate in 1967/68 in Ferozepur (table 3.2) as implying that 37 percent of the farmers, perhaps less, were planting high-yielding varieties. Such an interpretation has been used to support the contention that only large farmers are benefiting from introduction of new production technologies (54, p. 56). Closer examination of farm record data, however, shows how aggregate data tend to understate the proportion of farmers growing high-yield varieties. Farms sampled in Ferozepur and Thanjavur were stratified into five groups by size of farm. Within each stratum the proportion of farmers using high-yield varieties, in ascending order of farm size, were 70, 87, 60, 80, and 77 percent, respectively.

The discrepancy between the proportion of cultivated area sown to high-yield wheat and the proportion of farmers using high-yield varieties is explained as follows: While a large portion of the Ferozepur farmers had begun using high-yield wheat, relatively few (7 percent) had completely discontinued producing local varieties. The continued planting of local varieties in an area where high-yield varieties were widely used may be due to (1) a reserve acreage to be used mainly for home consumption, and (2) the probability that in 1967/68 many farmers in the sample were trying high-yield wheat for the first time.

27/ In Ferozepur, the largest farms (class 5) employed 2.2 times as much labor per farm as the smallest farms (class 1) (table 3.4). Yet, on the largest farms, the average number of family members (from which the supply of family labor is drawn) was only 1.5 times that of the smallest farms. In Thanjavur, the largest farms employed 5.7 times as much labor and had 1.4 times as many family members per farm as the smallest farms.

28/ Some progressive farmers are constructing tubewells to obtain a more manageable supply of irrigation water. However, because land in this district is only a few feet above sea level, tubewells are not apt to be widely used in Thanjavur. Tubewell irrigation, it is widely feared, could lower the fresh water table, thereby permitting salt water to enter and make the soil saline.

29/ Mean size of the sample farms in Thanjavur was 2.8 hectares. With an average of 11 fragments per farm unit, the average field size per farm was 0.25 hectare per field. This compares with a mean farm size of 12.6 hectares per farm in Ferozepur. Consequently, Thanjavur farms do not generally have large enough output volume to afford a large tractor, and do not have field sizes sufficiently large to make farm tractors operationally efficient.

30/ "F" ratios, derived from analysis of variance, were conducted to detect statistically significant differences in wage rates for hired labor among villages. Statistically significant differences (0.01 significance level) among villages were detected for both casual and permanent labor in Ferozepur. In Thanjavur, statistically significant differences (.05 significance level) were detected for casual labor, but not for permanent labor wages (76, p. 80).

31/ Material in this section was obtained primarily from personal interviews by the writer with farmers in the district. Also, see C. Muthiah (51, pp. 18-19) and Beteille (3, pp. 123-125).

32/ The price of family labor, for reasons described in chapter 3, has been deleted from all expressions explaining interfarm variations in family employment.

33/ The relations were initially tested using a function which was linear in the logarithms. These, however, obtained poor statistical results and were deleted from the final analyses (76, pp. 84-85).

34/ For an analysis of a jointly determined employment system, see (82, p. 787).

35/ Tractor ownership was included as a dummy variable but was not observed to be statistically significant. Hence, while the influence of tractor ownership was deleted from the final regression analyses, the influence of tractor ownership on farm employment is further considered in chapter 7.

36/ This variable is not included in the Thanjavur regressions.

37/ For details on the per hectare version of model 3 see (76).

38/ Theoretically, an employment elasticity for a given variable may exceed another with which the former is compared by a large amount, but yet the two may not significantly differ from one another. A confidence interval may be constructed, however, to test for significant differences between the elasticities compared. Such tests have been used previously by E. Heady and J. Dillon (25, p. 581) and R. Youmans and G. E. Schuh (88, pp. 943-961).

The test is conducted as follows. Suppose one wishes to determine the probability that the true employment elasticity for farm labor with respect to seed-fertilizer in Ferozepur ($E_{10,1,F}$) is less than that estimated in Thanjavur ($E_{10,1,T}$). The employment elasticities ($E_{i,j,k}$) are defined where i refers to the independent variable; j identifies the model in question, j = 1,2,3,1a and 2a; and k = F for Ferozepur, and T for Thanjavur. The employment elasticity is calculated as

$$\varepsilon_{i,j,k} = b_{i,j,k} \cdot \frac{\Sigma X_{i,j,k}}{\Sigma Y_{i,j,k}}$$

where, $b_{i,j,k}$ is the regression coefficient in question, $\Sigma X_{i,j,k}$ is the sum of the independent variable, and $\Sigma Y_{i,j,k}$ is the sum of the dependent variable in question.

The hypothesis to be tested is H_o: $\varepsilon_{10,1,F} = \varepsilon_{10,1,T}$. Using the formula above, the regression coefficient necessary to make $\varepsilon_{10,1,F} = \varepsilon_{10,1,T}$ is calculated algebraically. A confidence interval [($b_{10,1,T}$) - (required regression coefficient)] is identified. Using the estimated standard error of the regression coefficient ($sb_{10,1,F}$) a t-statistic is computed. Using this "t", H_o: $\varepsilon_{10,1,F} = \varepsilon_{10,1,T}$ is rejected at a confidence level of 0.05. The required $b_{10,1,F}$ is greater than that obtainable (given $sb_{10,1,F}$) within the 0.05 probability limits.

Where such comparisons are made the results of these tests are reported in the text. The tests themselves are reported in appendix A.

39/ In the per hectare version of model 2 for family labor (table A.8), bullock labor was the only statistically significant variable.

40/ The elasticity estimates for casual labor with respect to these variables exceed the employment elasticities estimated for family labor by an amount greater than the difference between elasticity estimates for permanent versus casual labor. However, the estimated standard errors of the regression coefficients for family labor were large. Consequently, significant differences were not detected between the employment elasticities for family labor with respect to the above-mentioned variables and comparable elasticity estimates for casual labor.

41/ The value of 1.5 is the quotient of:

$$\frac{s}{L_p} = \frac{103.9 \text{ man-days per farm}}{67.3 \text{ man-days per farm}}$$

The value of "s" is the reported standard error for the regression equation for permanent labor (table 5.5). The value of "L_p" is the arithmetic mean of permanent labor employed per farm.

42/ The employment relationships for family and hired labor were initially tested as a simultaneous system using simple least squares. That is, no adjustment was made in the initial experiments to correct for error bias in the regression coefficients caused by having more than one endogenous variable per equation. Because of possible bias in the regression coefficients in these initial regression experiments, no economic interpretation was derived from them. Nevertheless, these initial experiments implied that the underlying structural system was simultaneous rather than recursive in nature. That is, the quantity of family labor and the quantity of hired labor employed per farm were jointly determined.

43/ The coefficient of determination obtained for family labor in the two-stage analysis was much lower than that obtained in the initial experiments where single-stage least-squares procedures were employed. The initial experimental regressions for family labor included the actual quantities of hired labor (permanent and casual) as independent variables. In the two-stage analysis, however, the regression for family labor includes estimated quantities of permanent and casual labor as functional determinants. These estimated quantities are less widely distributed than the actual quantities of permanent and casual labor employed per farm, because the estimated quantities do not contain the "unexplained residual." That is, $\hat{Y} = Y - e_i$ where $\hat{Y}$ is the estimated value of Y, Y is the observed quantity of the variable in question, and e_i is the unexplained residual.

Extreme value for permanent and casual labor, when used as independent variables in the equation for family labor, are thereby eliminated in the two-stage analysis. The elimination of extreme values of these variables does correct for biases in the regression coefficients estimated for other variables. Suppression of the effects of these variables on family labor seems to be a cost of using this procedure.

44/ In Ferozepur, for example, wheat is produced in only one (the Rabi season) of two crop seasons. Further, during the Rabi season, wheat is produced on only a portion (55 percent) of the area sown. Of the total wheat area, only 37 percent was planted to high-yield varieties in 1967/68. Hence, the influence of percent HYV on employment is diffused when employment is measured over the entire farm business.

45/ This investment bias stems from the need to rapidly increase the total amount of food available. Wheat and rice are the two principal food crops, and when produced on irrigated land the yield of these crops can increase dramatically if fertilizer and other inputs are intensively used.

46/ On farms where the multiple-cropping ratio exceeds one, per hectare measures of resource use and farm production need to be adjusted for multiple cropping. Otherwise they will understate the total area actually cultivated and overestimate the level of resource use per unit of land area actually cultivated. To identify the degree of resource use within seasons, per hectare measures of resource use and farm production (see tables 7.1 and 7.3) are divided by the multiple cropping ratio.

47/ Observers in the U.S. Agency for International Development/INDIA estimate that 90 percent of the 1969/70 Punjab wheat crop was threshed mechanically. The transformation to this means of threshing occurred in 2 years. Reapers were not widely used in 1969/70, but were being used on a few innovative farms in Punjab. Both of these implements can be manufactured locally and can be purchased for less than Rs. 3,000 each. Consequently, the supply of these implements can be increased rapidly and they are economical on farms too small for tractor ownership.

48/ Cutting and stacking wheat by hand requires about 13 man-days of unskilled labor per hectare. With a bullock-drawn reaper, the same task requires 3 man-days of unskilled labor and 7.5 team-hours of bullock labor. Similarly, a diesel or electric thresher requires less than one-half the human labor per quintal of grain threshed as that required with the "bullock tramp-wind winnow method." The thresher eliminates the need for bullock labor as well (71, pp. 82-97).

49/ A reduction in the price of tractors may increase the number of farms purchasing tractors. As of 1970, however, the demand for farm tractors exceeded the supply. This was reflected in a black market premium alleged to be as high as Rs. 5,000, paid by persons wishing to be moved to the top of the waiting list. Also, while 10 hectares appears to be the minimum farm size on which large tractors are economically feasible, tractors were commonly used only on farms which averaged 25 hectares. These data, while not conclusive, suggest that many 10-hectare farms may continue to operate without tractors for some time.

50/ The price elasticities of demand for wheat, rice, and all major cereals in India have been estimated to be -0.19, -0.73, -0.34 respectively (55, p. 80).

51/ Other cases can be considered and would be instructive. However, for the sake of simple illustration, this single case is suitable for establishing the macro-considerations which determine the aggregate labor absorptive capacity of the farm sector.

52/ See appendix B.

53/ From 1950 to 1965, the real wage paid to farm laborers in India declined from an index of 100 to 85 (46, p. 48). It can be shown that, for a given rate of increase in income to, say, farm labor, an increase in farm wages occurs at the expense of an increase in total quantity of labor employed. See appendix B, p. 108.

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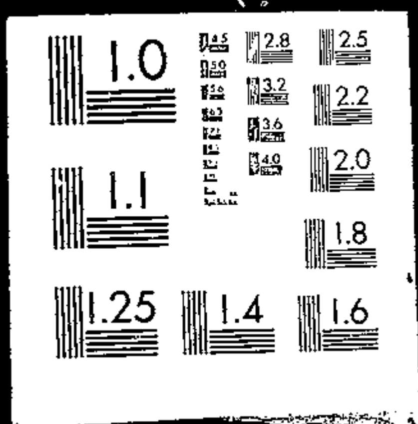

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APPENDIX A

Table A.1--Analysis of variance, wages paid casual and permanent labor on sample farms in Ferozepur, 1967/68

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Casual labor:				
Between villages.....	14	299.90	21.42	7.02
Within villages......	135	412.50	3.05	
Total.............	149	712.42	---	
Permanent labor:				
Between villages.....	14	119.28	8.52	2.94
Within villages......	83	241.21	2.90	
Total.............	97	360.49	---	

Table A.2--Analysis of variance, wages paid casual and permanent labor on sample farms in Thanjavur, 1967/68

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Casual labor:				
Between villages.....	14	9.37	0.669	1.94
Within villages......	135	46.44	.344	
Total.............	149	55.81	---	
Permanent labor:				
Between villages.....	13	5.51	0.424	1.35
Within villages......	54	16.88	.313	
Total.............	67	---	---	

Table A.3--Simple correlation coefficients among independent variables in per farm versions of models 1 and 2, Ferozepur, 1967/68

Variable	Farm size	Irrigation	Machinery	Bullock labor	Seed-fertilizer	Percent HYV	Wage, hired labor 1/	Family labor	Hired labor
Farm size.........	1.0000	0.3734	0.3786	0.3748	0.7354	0.0599	0.1630	0.1763	0.9254
Irrigation........		1.0000	.2430	.1868	.5424	.3395	.1697	.4775	.6142
Machinery.........			1.0000	-.0155	.4135	.0770	.1430	.0932	.3994
Bullock labor.....				1.0000	.2595	.0621	.0291	.5734	.4526
Seed-fertilizer...					1.0000	.3396	.3142	.3769	.8648
Percent HYV.......						1.0000	.3550	.1687	.1904
Wage, hired labor.							1.0000	.1371	.1186
Family labor......								1.0000	.3696
Hired labor.......									1.0000

1/ Wage hired labor, family labor, and hired labor are used only in the second stage of the two-stage least-squares regression of model 2.

Table A.4--Simple correlation coefficients among independent variables in per farm versions of models 1 and 2, Thanjavur, 1967/68

Variable	Farm size	Machinery	Bullock labor	Seed-fertilizer	Percent HYV	Wage, hired labor 1/	Family labor	Hired labor
Farm size	1.0000	0.4629	0.5601	0.4925	-0.0690	-0.0087	0.6861	0.7193
Machinery		1.0000	.1498	.1718	-.0720	-.0513	.2392	.3861
Bullock labor			1.0000	.8467	.0083	-.0179	.8469	.8509
Seed-fertilizer				1.0000	.0723	.1096	.9133	.8534
Percent HYV					1.0000	.0772	-.0242	.0483
Wage, hired labor						1.0000	.0860	-.0134
Family labor							1.0000	.7851
Hired labor								1.0000

1/ Wage hired labor, family labor, and hired labor are used only in the second stage of the two-stage least-squares regression of model 2.

Table A.5--Simple correlation coefficients among independent variables in per hectare versions of models 1 and 2, Ferozepur, 1967/68

Variable	Farm size	Irrigation	Machinery	Bullock labor	Seed-fertilizer	Percent HYV	Wage, hired labor 1/	Family labor	Hired labor
Farm size.........	1.0000	-0.1765	0.0599	-0.3927	0.0200	0.0598	0.1629	-0.7054	0.1678
Irrigation........		1.0000	.0075	.2329	.4258	.3552	.1454	.4277	.5368
Machinery.........			1.0000	.0281	.1111	.0197	.0871	.0193	.0329
Bullock labor.....				1.0000	.1972	.0997	-.0539	.8781	.1328
Seed-fertilizer...					1.0000	.5262	.3954	.3444	.8119
Percent HYV.......						1.0000	.3550	.1622	.4292
Wage, hired labor.							1.0000	-.0405	-.0341
Family labor......								1.0000	.2372
Hired labor.......									1.0000

1/ Wage hired labor, family labor, and hired labor are used only in the second stage of the two-stage least-squares regression in model 2.

Table A.6--Simple correlation coefficients among independent variables in per hectare versions of models 1 and 2, Thanjavur, 1967/68

Variable	Farm size	Machinery	Bullock labor	Seed-fertilizer	Percent HYV	Wage, hired labor 1/	Family labor	Hired labor
Farm size	1.0000	0.1725	-0.1853	-0.1040	-0.0690	-0.0086	-0.6250	-0.0626
Machinery		1.0000	.0711	.1190	.0449	-.0205	.2543	.1100
Bullock labor			1.0000	.7537	.0449	.0389	.6942	.8401
Seed-fertilizer ..				1.0000	.0834	.1480	.6597	.9430
Percent HYV					1.0000	.0772	-.1062	.1364
Wage, hired labor						1.0000	.0653	-.0297
Family labor							1.0000	.6388
Hired labor								1.0000

1/ Wage hired labor, family labor, and hired labor are used only in the second stage of the two-stage least-squares regression in model 2.

Table A.7--Test for significant differences in employment elasticities for per farm version of model 1 (table 5.1), Ferozepur and Thanjavur, 1967/68 1/

Independent variable	Regression coefficient required Ferozepur equation to equal employment elasticity estimated for Thanjavur (1)	Actual regression coefficient estimated in Ferozepur equation (2)	Confidence interval (1) - (2) (3)	$s(b_i)$ estimated standard error of actual regression coefficient (4)	t = confidence interval divided by $s(b_i)$ (5)	Reject or fail to reject H_o at the 0.05 level
Farm size....	18.3859	16.1709	2.2150	4.4183	0.50	Fail
Machinery....	.0043	.0011	.0032	.0028	1.14	Fail
Bullock labor......	.9877	.8112	.1765	.1569	1.12	Fail
Seed-fertilizer......	.1568	.0875	.0693	.0235	2.95	Reject

1/ The hypothesis is H_o: the estimated $(b_{i,1,F})$ = the $(b_{i,1,F})$ required to make $\varepsilon_{i,1,F}$ equal to the actual $\varepsilon_{i,1,T}$. The critical t = 1.96 which tests for significant differences at the 0.05 level.

Table A.8--Regression coefficients, standard errors, and employment elasticities for family and hired labor per hectare, model 2, two-stage least squares, Ferozepur, 1967/68

Independent variable	Family labor per hectare		Hired labor per hectare	
	Regression coefficient (std. error)	Employment elasticity	Regression coefficient (std. error)	Employment elasticity
Constant	21.7705	---	17.5476	---
Farm size	1/ -1.0693* (.2512)	-0.3400	.6112 (.8057)	.1984
Irrigation	.0589 (.0518)	.0705	.0462 (.0640)	.0565
Machinery	-.0008 (.0023	-.0066	-.0003 (.0023)	-.0031
Bullock labor	.9233* (.1369)	.5160	-.2667 (.6894)	-.1521
Seed-fertilizer	.0443 (.0422)	.1661	.0859* (.0458)	.3288
Percent HYV	-.0271 (.0646)	-.0205	.0340 (.0646)	.0263
Wage, hired labor	---	---	-1.5427 (1.1650)	-.1964
Family labor	---	---	.2836 (.7316)	.2903
Hired labor	.0670 (.3318)	.0660	---	---
R^2	.489	---	.177	---
f	19.397	---	3.806	---
s	21. 657	---	21.292	---

1/ The asterisk identifies those variables whose coefficients are statistically significant at the 0.10 level or more.

Table A.9--Test for significant differences in employment elasticities for per hectare version of model 1 (table 5.1), Ferozepur and Thanjavur, 1967/68 1/

Independent variable	Regression coefficient required in Ferozepur equation to equal employment elasticity estimated for Thanjavur (1)	Actual regression coefficient estimated in Ferozepur equation (2)	Confidence interval (1) - (2) (3)	$s(b_i)$ estimated standard error of regression coefficient (4)	t = confidence interval divided by $s(b_i)$ (5)	Reject or fail to reject H_o at the 0.05 level
Farm size....	-0.5108	-0.7727	0.2619	0.2105	1.24	Fail
Irrigation...			NO TEST POSSIBLE			
Machinery....	.0020	-.0017	.0037	.0020	1.85	Fail
Bullock labor......	.7745	.9371	.1626	.1231	1.32	Fail
Seed-fertilizer......	.2109	.1400	.0709	.0248	2.86	Reject

1/ The hypothesis is H_o: the estimated $(b_{i, l_a, F})$ = $(b_{i, l_a, F})$ required to make $\varepsilon_{i, l_a, F}$ equal to the actual $\varepsilon_{i, l_a, T}$. The critical t = 1.96 which tests for significant differences at the 0.05 level.

Table A.10--Test for significant differences in employment elasticities for family versus hired labor, per farm version of model 2 (table 5.2), Ferozepur and Thanjavur, 1967/68 1/

	Regression coefficient required in family labor equation to equal employment elasticity estimated for hired labor (1)	Actual regression coefficient estimated in family labor equation (2)	Confidence interval (1) - (2) (3)	$s(b_i)$ estimated standard error of regression coefficient (4)	t = confidence interval divided by $s(b_i)$ (5)	Reject or fail to reject H_o at the 0.05 level
Ferozepur:						
Farm size..	12.4861	-12.9471	25.4332	11.2583	2.26	Reject
Irrigation.	.1866	.0820	.1046	.0891	1.17	Fail
Machinery..	.0001	.0006	.0005	.0026	.19	Fail
Bullock labor....	.5705	.5143	.0562	.1863	.30	Fail
Seed-fertilizer....	.1993	.0256	.1737	.0336	5.17	Reject
Thanjavur:						
Farm size..	11.4763	3.4781	7.9982	1.7477	4.58	Reject
Machinery..	.0048	.0008	.0040	.0030	1.33	Fail
Bullock labor....	.2435	.0620	.1815	.0729	2.49	Reject
Seed-fertilizer....	.1843	.0628	.1215	.0207	5.87	Reject

1/ The hypothesis is H_o: the estimated $(b_{i,\ 2,\ k})$ for family labor = the $(b_{i,\ 2,\ k})$ required to make $(\varepsilon_{i,\ 2,\ k})$ family labor equal to $(\varepsilon_{i,\ 2,\ k})$ hired labor. The critical t = 1.96 which tests for significant differences at the 0.05 level.

Table A.11--Test for significant differences in employment elasticities between total labor in per farm version of model 1 (table 5.1) and hired labor in per farm version of model 2 (table 5.2), Ferozepur and Thanjavur, 1967/68 1/

Independent variable	Regression coefficient required in per farm version of model one to equal employment elasticities estimated for hired labor in per farm version of model 2 (1)	Actual regression coefficient estimated in per farm version of model 1 (2)	Confidence interval (1) - (2) (3)	$s(b_i)$ estimated standard error of regression coefficient (4)	t = confidence interval divided by $s(b_i)$ (5)	Reject or fail to reject H_o at the 0.05 level
Ferozepur:						
Farm size...	29.2366	16.1709	13.0657	4.4182	2.95	Reject
Irrigation..	.4372	.2615	.1757	.0574	3.06	Reject
Machinery...	.0020	.0011	.0009	.0028	.32	Fail
Bullock labor.....	1.3353	.8112	.5241	.1569	3.34	Reject
Seed-fertilizer.....	.1541	.0875	.0666	.0235	2.83	Reject
Thanjavur:						
Farm size...	48.3697	19.7592	28.6105	3.9282	7.28	Reject
Machinery...	.0211	.0214	.0003	.7670	.00	Fail
Bullock labor.....	1.0268	.6464	.3804	.1710	2.22	Reject
Seed-fertilizer.....	.7777	.2730	.5047	.0451	11.19	Reject

1/ The hypothesis is H_o: the estimated $(b_{i, 1, k}) = (b_{i, 2, k})$ hired labor required to make $\varepsilon_{i, 1, k}$ equal to the actual $(\varepsilon_{i, 2, k})$ hired labor. The critical t = 1.96 which tests for significant differences at the 0.05 level.

Table A.12--Test for significant differences in employment elasticities for hired labor in per farm version of model 2 (table 5.2) between Ferozepur and Thanjavur, 1967/68 1/

Independent variable	Regression coefficient required in Ferozepur hired labor equation to equal employment elasticity estimated for Thanjavur hired labor (1)	Actual regression coefficient estimated for hired labor in Ferozepur (2)	Confidence interval (1) - (2) (3)	$s(b_i)$ estimated standard error of regression coefficient (4)	t = confidence interval divided by $s(b_i)$ (5)	Reject or fail to reject H_o at the 0.05 level
Farm size	25.7813	16.7472	9.0341	4.0452	2.23	Reject
Irrigation	NO TEST POSSIBLE					
Machinery	.0023	.0011	.0012	.0023	.52	Fail
Bullock labor	.8991	.7652	.1339	.1689	.79	Fail
Seed-fertilizer	.2556	.0882	.1674	.0210	7.97	Reject
Family labor	-.0358	-.9266	.8908	.1898	4.65	Reject

1/ The hypothesis is H_o: the estimated $(b_{i, 2, F}) = (b_{i, 2, F})$ required to make $\varepsilon_{i, 2, F}$ equal to the actual $\varepsilon_{i, 2, T}$. The critical t = 1.96 which tests for significant differences at the 0.05 level.

Table A.13--Test for significant differences in employment elasticities between hired and family labor in per hectare version of model 2 (table 5.3), Thanjavur, 1967/68 1/

Independent variable	Regression coefficient required in family labor equation to equal the employment elasticity estimated for hired labor (1)	Actual regression coefficient in the family labor equation (2)	Confidence interval (1) - (2) (3)	$s(b_i)$ estimated standard error of regression coefficient (4)	t = confidence interval divided by $s(b_i)$ (5)	Reject or fail to reject H_o at the 0.05 level
Farm size.......	1.7154	-1.3305	3.0459	0.2996	10.16	Reject
Irrigation......	.4317	.2402	.1915	.2144	.89	Fail
Machinery.......	.0375	.0319	.0056	.0172	.33	Fail
Bullock labor...	.3241	.2105	.1136	.1156	.98	Fail
Seed-fertilizer.	.1936	.1085	.0854	.0698	1.22	Fail

1/ The hypothesis is H_o: the estimated $(b_{i,\ 2_a,\ T})$ family labor = $(b_{i,\ 2_a,\ T})$ hired labor required to make $(\varepsilon_{i,\ 2_a,\ T})$ family labor equal to the actual $(\varepsilon_{i,\ 2_a,\ T})$ hired labor. The critical t = 1.96 which tests for significant differences at the 0.05 level.

Table A.14--Simple correlation coefficients among variables in per farm version of model 3, Ferozepur, 1967/68

Variable	Farm size	Irrigation	Machinery	Bullock labor	Seed-fertilizer	Percent HYV	Wage permanent labor	Wage casual labor	Family labor 1/	Permanent labor	Casual labor
Farm size....	1.0000	0.3734	0.3786	0.3748	0.7354	0.0599	0.0414	0.0986	0.1763	0.8466	0.9318
Irrigation...		1.0000	.2430	.1868	.5424	.3395	.0165	.1344	.4775	.6784	.4636
Machinery....			1.0000	-.0155	.4135	.0770	.1384	.0371	.0933	.2996	.4891
Bullock labor				1.0000	.2595	.0621	-.0860	.2085	.5734	.5074	.3324
Seed-fertilizer......					1.0000	.3396	.0515	.3218	.3768	.9101	.7135
Percent HYV..						1.0000	.2787	.2573	.1687	.2758	.0573
Wage permanent labor.							1.0000	.0999	-.0604	-.0240	.0191
Wage casual labor......								1.0000	.3184	.2656	-.1905
Family labor.									1.0000	.4824	.1812
Permanent labor......										1.0000	.8186
Casual labor.											1.0000

1/ Family labor, permanent labor, and casual labor are the values for these respective variables obtained in the first stage of the two-stage least squares regression.

Table A.15--Test for significant differences in employment elasticities between permanent and casual labor in per farm version of model 3 (table 5.4), Ferozepur, 1967/68 1/

Independent variable	Regression coefficient required in the permanent labor equation to equal the employment elasticity estimated for casual labor (1)	Actual regression coefficient estimated in the permanent labor equation (2)	Confidence interval (1) - (2) (3)	$s(b_i)$ estimated standard error of regression coefficient (4)	t = confidence interval divided by $s(b_i)$ (5)	Reject or fail to reject H_o at the 0.05 level
Farm size........	3.0479	9.2197	6.1718	6.1877	1.00	Fail
Irrigation.......	.3702	.1582	.2120	.0479	4.43	Reject
Machinery........	-.0022	-.0012	.0010	.0023	.43	Fail
Bullock labor....	.9991	.4610	.5381	.1431	3.76	Reject
Seed-fertilizer..	.1776	.0693	.1083	.0176	6.15	Reject
Wage rate........	-23.6077	-8.2656	15.3421	10.6488	1.44	Fail
Family labor.....	-.5907	-.3899	.2008	.1617	1.24	Fail

1/ The hypothesis is H_o: the estimated $(b_{i,\ e,\ F})$ permanent labor = $(b_{i,\ 3,\ F})$ permanent labor required to make $(\varepsilon_{i,\ 3,\ F})$ permanent labor equal to the actual $(\varepsilon_{i,\ 3,\ F})$ casual labor. The critical t = 1.96 which tests for significant differences at the 0.05 level.

Table A.16--Simple correlation coefficients among variables in per farm version of model 3, Thanjavur, 1967/68

Variable	Farm size	Machinery	Bullock labor	Seed-fertilizer	Percent HYV	Wage permanent labor	Wage casual labor	Family labor 1/	Permanent labor	Casual labor
Farm size......	1.0000	0.4629	0.5601	0.4925	-0.0690	0.0017	0.0610	0.6861	0.6761	0.7339
Machinery......		1.0000	.1498	.1718	-.0720	.0310	-.0397	.2392	.2716	.7217
Bullock labor..			1.0000	.8467	.0083	.0219	.0361	.8469	.8885	.5509
Seed-fertilizer				1.0000	.0723	-.0624	.1651	.9133	.8722	.6250
Percent HYV....					1.0000	-.1887	.0914	-.0242	.0515	-.0274
Wage permanent labor.........						1.0000	-.2636	.0165	.2295	.0100
Wage casual labor.........							1.0000	.1436	.0051	.0067
Family labor...								1.0000	.7957	.6026
Permanent labor									1.0000	.7845
Casual labor...										1.0000

1/ Family labor, permanent labor, and casual labor are the values for these variables obtained in the first stage of the two-stage least-squares regression.

Table A.17—Regression coefficients, standard errors, and employment elasticities for per farm version of model 3 on farms which employ permanent labor, Thanjavur, 1967/68 1/

Independent variable	Family labor: Regression coefficient (std. error)	Family labor: Employment elasticity	Permanent labor: Regression coefficient (std. error)	Permanent labor: Employment elasticity	Casual labor: Regression coefficient (std. error)	Casual labor: Employment elasticity
Constant	130.3418	---	-287.671	---	437.3762	----
Farm size	2/ 5.5271* (2.0237)	0.3878	7.9382* (3.6146)	0.5388	9.1740 (6.4722)	0.1895
Machinery	-.0010 (.0034)	-.0065	.0142* (.0052)	.0925	.0046 (.0103)	.0090
Bullock labor	.0690 (.0821)	.1412	-.0246 (.1368)	-.0438	.5913* (.2424)	.3562
Seed-fertilizer	.0712 (.0218)	.4916	.0579 (.0399)	.3867	.2477* (.0669)	.5036
Percent HYV	-.6714 (.5003)	-.3829	.4540 (.8590)	.2505	-.6140 (1.5602)	-.1031
Wage, permanent labor	---	---	121.1206 (54.6769)	1.9505	---	---
Wage, casual labor	---	---	---	---	-78.1265 (52.3777)	-.4847
Family labor	---	---	-.1909 (.2195)	-.1848	-1.3988* (.3513)	-.4119
Permanent labor	-.0267 (.0755)	-.0276	---	---	.1296 (.2336)	.0394
Casual labor	-.1520* (.0368)	-.5164	-.0110 (.0708)	-.3628	---	---
R^2	.416	---	.412	---	.700	---
f	6.103	---	5.159	---	17.236	---
s	86.374	---	142.961	---	264.730	---

1/ Two-stage least-squares estimates of the above relations obtained a high degree of multicolinearity between seed-fertilizer and the first-stage estimate of family, permanent, and casual labor. Consequently, the above relations were estimated via simple least-squares regression.

2/ The asterisk identifies those variables whose coefficients were significant at the 0.10 level or more.

APPENDIX B

Growth in Gross Agricultural Revenue, Labor's Share, and Agricultural Labor Absorption

The rate of growth of agricultural employment opportunities can be analyzed in terms of the rate of change in income to farm labor relative to the rate of change in gross revenue to agriculture. This frame of reference is based on the concept that the total value of farm production is completely allocated among the various factors of farm production--land, labor, and capital. If one assumes that each input is valued according to its marginal contribution to gross revenue, the total value of farm production is the sum of the income allocated to land, labor, and capital, respectively. This can be written:

$$(1)\quad Y = L + N + K$$

where, L, N, and K are the incomes paid to land, labor, and capital, respectively.

The share of income allocated to each factor is the proportion of total income to agriculture paid to each factor. This can be derived by dividing equation (1) by Y:

$$(2)\quad \frac{Y}{Y} = \frac{L}{Y} + \frac{N}{Y} + \frac{K}{Y}$$

Since this analysis is concerned with labor absorption in agriculture, attention is focused on the income share paid farm labor (s_L)--the portion of total farm revenue paid farm labor.

$$(3)\quad s_L = \frac{N}{Y} = \frac{W.Q}{Y}$$

The total income paid farm labor (N) is the product of the average wage (W) and the quantity of labor (Q) actually employed -- N = WQ.

To focus particular attention on determinants of employment, equation (3) is transposed to treat Q as the dependent variable:

$$(4)\quad Q = \frac{s_L.Y}{W}$$

The absolute change in farm employment per unit of time is the total time derivative of (4):

$$(5) \quad \dot{Q} = \frac{s_L}{W} \cdot \dot{Y} + \frac{Y}{W} \cdot \dot{s}_L - \frac{s_L Y}{W^2} \dot{W}$$

The rate of change in farm employment per unit of time can be obtained by dividing (5) by Q:

$$(6) \quad \frac{\dot{Q}}{Q} = \frac{1}{Q} \left(\frac{s_L}{W} \cdot \dot{Y} + \frac{Y}{W} \cdot \dot{s}_L - \frac{s_L Y}{W^2} \cdot W\right)$$

Since $1/Q = W/s_L Y$, equation (6) can be simplified to read

$$(7) \quad \frac{\dot{Q}}{Q} = \frac{\dot{Y}}{Y} + \frac{\dot{s}_L}{s_L} - \frac{\dot{W}}{W}.$$

The rate of growth in farm employment ($\dot{Q}/Q$), therefore, depends on the rate of change in (1) the total value of farm output, (2) the income share paid farm labor, and (3) wages paid farm labor. Of the three factors, the rate of change in the total value of farm production will have the greatest short-run effect on farm labor absorption.

Changes in the income share paid farm labor (s_L), while directly related to the rate of change in farm employment, occur gradually over time (43, 45). This is because, in the absence of technological change, relatively large increases in the price of labor relative to capital will induce only minor changes in the income share paid farm labor. The changes are minor even when the elasticity of substitution between labor and capital differs markedly from one (45, p. 940). Changes in the income share paid farm labor occur slowly, because they depend on the introduction of biased technological inputs which increase the use of the cheapest factor relative to those which are more expensive (45, p. 944). Such innovations and their application occur slowly over time.

The rate of growth in farm employment is inversely related to the rate of change in farm wages. This stems from the tendency to reduce the amount of labor used in production relative to capital as the price of labor increases relative to capital. Given widespread unemployment and underemployment, increases in the price of farm labor may not be large. However it is important to note that (1) measures which artificially cause farm wages to increase and (2) decreases in the price of farm capital (increased supply of capital) relative to labor will reduce the rate of increase in farm employment. Further, such changes in relative prices stimulate the development and manufacture of innovations which facilitate the substitution of capital for labor.

In closing, it is worth noting that the rate of increase in income paid farm labor is frequently considered to depend on the rate of increase in labor productivity and wages. Total income to farm labor, however, is the product of the wage times the quantity employed. Consequently, total income paid farm labor may increase without increases in farm wages. Where a relative shortage of employment opportunities is a major cause of low incomes to farm labor, increasing farm wages is neither a likely nor a desirable instrument for improving rural labor incomes.

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