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THE EFFECT OF THE NEW RICE TECHNOLOGY ON FAMILY LABOR UTILIZATION IN LAGUNA

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THE EFFECT OF THE NEW RICE TECHNOLOGY ON FAMILY LABOR UTILIZATION IN LAGUNA[1]

ABSTRACT

This paper analyzes the changes in labor utilization in Laguna province, Philippines, since the introduction of the new rice technology. Until 1970, the crop care activities required by the new rice technology were met by an increase in labor utilization. After 1975, labor began to be replaced by chemicals and machinery.

Family labor has been increasingly replaced by hired labor because:

- with the change in technology, *hired operations* contribute more than *family operations* toward increasing rice production;
- the productivity of management time has gone up;
- the cropping pattern has been diversified to include watermelon, a highly labor-intensive but profitable crop;
- the greater availability of salaried nonfarm jobs has raised the opportunity cost of farm work; and
- increased farm incomes increased the farmer's capacity to pay for hired labor.

The changes in labor utilization, following technical change, are a telescoped version of the Japanese-Taiwanese structural transformation model.

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THE EFFECT OF THE NEW RICE TECHNOLOGY ON FAMILY LABOR UTILIZATION IN LAGUNA

Papers on the consequences of the new rice technology have explored such vital issues as yield gap, income distribution, and mechanization. This study fills a gap that has remained unexplored. We focus on the key figures in the drama of the so-called *green revolution* -- the farmer and his family.

How has the new technology affected the farmer, his family, and their employment patterns? Barker and Cordova (1976) report that farmers are now delegating the more-backbreaking tasks of rice production to those lower down on the *agricultural ladder* -- the landless laborers. What is responsible for this shift away from family labor? Are the farmer and his family making productive use of the time previously spent in rice production or are they merely increasing their consumption of leisure?

The data we analyzed pertain to 45 Laguna farmers surveyed by IRRI on four occasions. The earliest survey was in 1965, just before the introduction of the new rice varieties.

The study municipalities (Biñan, Cabuyao, and Calamba) lie along a main road from Los Baños to Manila (Fig. 1). Consequently, the farmers surveyed have been simultaneously exposed to advanced technological practices and industrialization. With average rice yields of 4.1 t/ha per crop vs 1.9 for the nation, they are obviously not representative of the Filipino farmer. They are, however, interesting as models of possible future developments, as technological change and industrialization spread to other parts of the country.

Important changes in the cultivation practices of these farmers have taken place since 1965. Foremost among them was the introduction of the new rice varieties in 1966. The farmers readily adopted the new varieties. By 1970, 96% of them had switched to modern varieties (MV). By 1975 adoption was 100%. Yield per planted area and the rice cropping index increased (Table 1).

Implementation of land reform regulations from 1972 resulted in a dramatic decline in share-tenancy and 69% of the Laguna farmers were leaseholders by 1978 (Table 2). The cropping pattern has become more complex. In 1965, 82% of the farmers grew only rice. By 1978 31% of them had added watermelon to their cropping pattern and 47% grew vegetables (Table 3).

CHANGES IN LABOR UTILIZATION

Several studies have shown that MV require more crop care activities such as fertilization, and weed, insect, and water control (Barker and Cordova 1976). Until the mid-1970s these requirements were met by increasing labor use. Total labor per hectare in Laguna rose from 86 days/ha in 1965 (before MV) to 112 in 1975, a 31% increase. From the mid-1970s, chemicals and machinery gradually replaced labor. As a result, in 1978 labor use fell back to pre-MV levels (Table 4).

Analyzing the changes in labor use by operation, we found that land preparation labor declined steadily throughout the period as a result of increased mechanization. By 1978 harrowing was almost completely mechanized and 47% of the farmers used tractors for plowing. In contrast, in 1965 plowing was universally done by carabao and only 24% of the farmers harrowed with a tractor (Table 5). Land preparation by tractor reduces turnaround time -- time between crops. In addition, in Laguna today, mechanized harrowing costs less on a per hectare basis than harrowing by carabao (Table 6). This is probably a function of the decrease in the supply of carabaos relative to tractors. Between 1965 and 1978 while carabao owners decreased from 76 to 36% of the sample, tractor owners increased from 15 to 27% (Table 7).

The decline in land preparation labor was more than offset by the increase in weeding labor, which almost tripled from 11 days/ha in the pre-MV period to 32 in 1975 (Table 4). This is because the short stature and erect leaves of the MV delay the formation of a canopy to block solar radiation to weeds until 30 to 40 days after transplanting (DT) (Moody 1979). Competition from weeds, therefore, increases in the early part of the growing season.

From 1975, labor intensity followed an opposite trend. Seventy-four percent of the sample switched from manual to mechanical threshing. The change was enhanced by the availability of an IRRI-designed axial flow thresher in 1976, and speeded by an increase in real agricultural wage (Table 8). Other factors contributing to the switch could be the ease of threshing, shorter turnaround time, and lower postharvest losses. In 1978, weeding labor decreased to 84% of its 1975 level. This was accompanied by an increase in the use of herbicides (Fig. 2) and increased efficiency of herbicide use, as farmers shifted from postemergence (20 to 25 DT) to preemergence (3 DT) application.

The drop in weeding labor was apparently an attempt by the farmer to adapt to changing relative factor prices (Fig. 3). From 1970 to 1975 as herbicide prices increased and real agricultural wages fell, farmers' weed control was mainly by hand weeding. From 1975 to 1978 real wages increased and herbicide prices stabilized (due to government control) and farmers increased use of herbicides.

Table 1. Changes in rice farming, Laguna, Philippines, 1965-78.

Factor	Farmers (%) 1965	1970	1975	1978
Farm size (ha)	2.3	2.2	2.3	2.3
Rice cropping index	1.8	1.7	2.0	2.0
Yield (t/ha per crop)	2.5	3.5	3.6	4.1
Cultivation of MV (% farmers)	0	96	100	100

Table 2. Changes in tenure status, Laguna, Philippines, 1965-78.

Tenure status	Farmers (%) 1965	1970	1975	1978
Owner operator	0	2.2	2.2	2.2
Leaseholder	11.1	20.5	60.0	68.9
Share tenant	86.7	77.3	31.1	15.6
Combination of the above	2.2	0	6.7	13.3

Table 3. Changes in cropping pattern, Laguna, Philippines, 1965 and 1968.

Cropping pattern	Farmers (%) 1965	1978
Rice only	82	22
Rice and vegetables	18	47
Rice and watermelon	0	31

Table 5. Laguna, Philippines, farmers (%) with mechanized land preparation, 1965-78.

Operation	1965	1970	1975	1978
Plowing	0	11	20	47
Harrowing	24	69	89	93

Table 6. Harrowing cost (expenses and final leveling) at current values, Laguna, 1965-78.[a]

Year	Hired tractor and operator (₱/ha)[a]	Hired carabao and operator (₱/ha)[b]
1965	68	42
1970	69	72
1975	140	187
1978	228	243

[a]Source: Roumasset and Smith 1979. [b]US$1 = ₱7.35.

Table 7. Laguna, Philippines, farmers (%) owning tractors and carabaos, 1965, 1975, and 1978.

	1965	1975	1978
Tractor owners	15.5	17.8	26.7
Carabao owners	75.6	57.8	35.6

Table 4. Changes in labor use in rice production, Laguna, Philippines, 1965-78 wet seasons.

Farming operations	Family labor (work days/ha) 1965	1970	1975	1978	Hired labor (work days/ha) 1965	1970	1975	1978	Total labor[a] (work days/ha) 1965	1970	1975	1978
Land preparation	14.4	5.7	4.5	2.7	4.0	5.1	6.0	6.5	19.2	11.4	10.6	9.2
Repair and cleaning of dikes	3.8	3.8	3.5	3.3	.2	.9	1.1	1.5	4.2	4.9	4.7	5.2
Transplanting	.2	0	0	0	9.6	10.6	11.3	10.0	9.8	10.7	11.3	10.0
Weeding	9.0	6.7	5.9	4.8	2.1	12.1	25.6	21.8	11.1	19.1	31.6	26.6
Fertilizing and spraying	.9	1.5	2.3	1.7	0	.1	.5	0.7	.9	1.6	3.0	2.6
Other preharvest operations[b]	3.7	7.5	4.9	3.6	.7	1.5	9.7	0.4	4.5	9.1	14.7	4.2
Total preharvest labor	32.0	25.2	21.1	16.1	16.6	30.3	54.2	40.9	49.7	56.8	75.9	57.8
Harvesting, threshing, and postharvest activities	.5	1.6	.8	.7	34.6	35.7	35.0	27.1	35.8	37.3	35.8	27.8
Total labor	32.5	26.8	21.9	16.8	51.2	66.0	89.2	68.0	85.5	94.1	111.7	85.6

[a]Includes exchange labor. [b]Seedbed preparation, pulling and rolling seedlings, replanting.

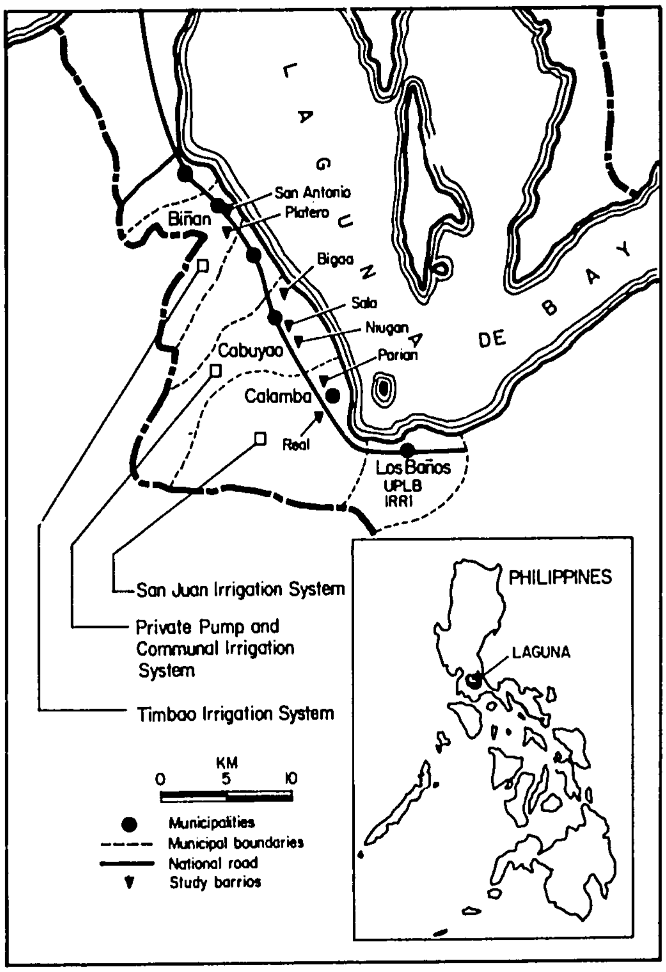

Fig. 1. Map of Laguna province, Philippines, showing location of study barrios and sources of irrigation.

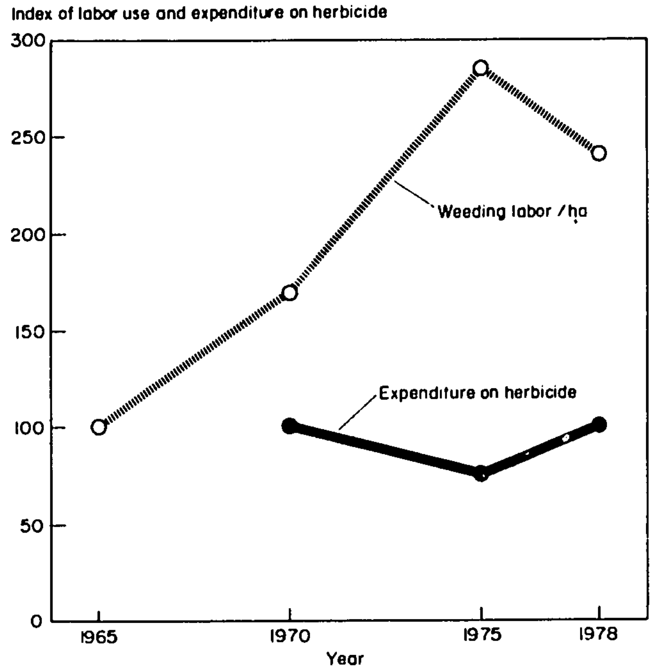

Fig. 2. Weeding labor and expenditure on herbicide by 45 Laguna farmers, 1965-78.

HIRED LABOR VS FAMILY LABOR

Family labor declined steadily in absolute as well as percentage terms throughout the period of the study (Fig. 4). The most significant changes took place in land preparation and weeding (Table 4).

There was a dramatic decrease in family land preparation labor, from 14.5 days/ha in 1965 to 2.7 in 1978, a drop to 18% of its previous level. Much of this decrease was, of course, caused by the mechanization of land preparation. Family labor also dropped in percentage terms, indicating some substitution of hired labor for family labor (Fig. 5). In Laguna, tractors cannot usually be hired without the operators. Consequently, if a farmer is not a tractor owner, the shift to mechanized land preparation automatically implies a switch to hired labor (Roumasset and Smith 1979).

In 1965, weeding was essentially a family operation. Only 19% of the labor used was hired. By 1978, the picture was the reverse. Family labor had dropped to almost half its pre-MV level and the family accounted for only 19% of the total weeding labor (Fig. 5). Farmers claimed that the introduction of MV had changed the nature of the weeding operation. Very large amount of weeding work had to be completed within the span of a few days -- a task the family was unable to handle, because of its limited size. On an average farm of about 2.3 ha, 61 days of weeding had to be completed in about 5.6 days (Table 9). Because each family had an average of 5.8 persons 10 years old and above (Table 10), the task could not be completed by the family alone. This is possibly one reason why weeding today, like harvesting, threshing, and transplanting, is predominantly done by hired laborers.

Why should the weeding be completed within a few days? Farmers in Laguna tend to do the first weeding and the first application of fertilizer within a few days of each other. Fertilizer is applied either immediately after weeding or immediately preceding the first rotary weeding (the rotary weeder incorporates the fertilizer into the soil). Either way, weeds need to be removed as soon as possible, to prevent them from absorbing fertilizer nutrients. Kim and Moody (1979) point out that weeds, because of their plasticity and nonuniform germination, are able to absorb nitrogen more efficiently than the rice plant. This is particularly true of *Monochoria vaginalis*, one of the most common weeds in transplanted rice. A study by Deomampo and Barker (1969) provides additional support for the

Table 8. Changes in agricultural wages for 45 Laguna farmers, 1965-1978.

	Daily wages (current values)				Index of real wages[a]			
	1965	1970	1975	1978	1965	1970	1975	1978
Harvesting and threshing (kg rice)	9.9	13	8.7	10.9	100	131	88	110
Transplanting (₱)	3.4	5.4	8.5	12.6	100	121	81	92

[a]Transplanting wage deflated by Consumer Price Index outside Manila. Sources: IRRI and PCARR 1976, *1965 to 1975 Data series on rice statistics, Philippines*; NEDA National Census and Statistics Office 1978 (unpublished mimeo).

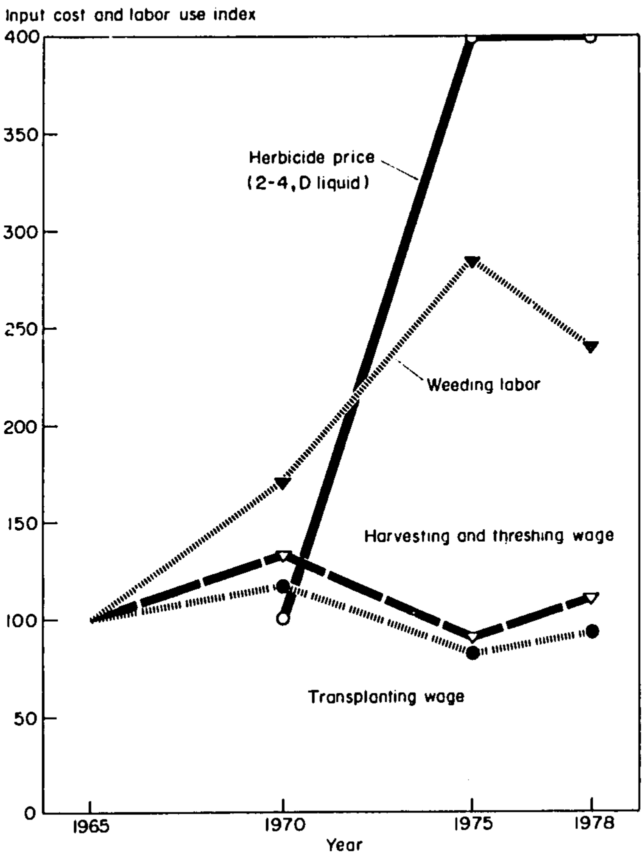

Fig. 3. Effect of relative input costs on weeding labor for 45 Laguna farmers, 1965-78. The transplanting and harvesting and threshing wages were used in computing the weeding wage. The weeding wage is difficult to compute because under the *gama* system currently practiced in Laguna, a combined payment is made for weeding, harvesting, and threshing.

importance of timely weeding. The optimum weeding time was calculated to be 16 to 18 DT. After that time, net and gross returns to weeding fell sharply. Farmers are obviously aware of the importance of timely weeding. Fifty-six percent of our sample completed the first weeding in 2 days or less, and 88% took no longer than 7 days.

Figure 6 shows the range of the timing of different operations by our sample farmers in 1978. Note the proximity of the mode of the fertilizing and weeding operations.

Estimation of Cobb-Douglas production function to explain increase in hired labor relative to family labor

The new technology heightened farmers' awareness of the importance of timeliness in rice farming operations. Certain tasks like harvesting, threshing, transplanting, and weeding have high labor requirements and it is impossible to complete the task within a specified crop growth stage without hiring substantial quantities of labor. For some other

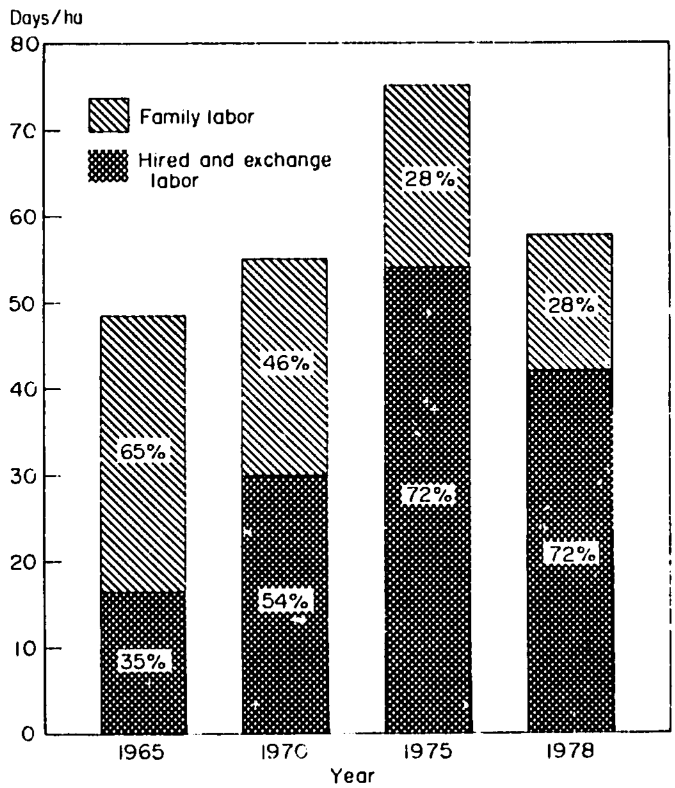

Fig. 4. Composition of preharvest labor for 45 Laguna farmers, 1965-78.

operations, such as fertilizing and spraying insecticide, timing is equally vital, but because labor requirements are small (2.6 days/ha), the tasks can be done by the family. The essential criterion separating the two types of operations is whether it is *possible* for an average family to complete the task within the specified number of days. Three factors determine this: 1. per-farm labor requirements for the task; 2. time span during which the operation must be completed; and 3. family size.

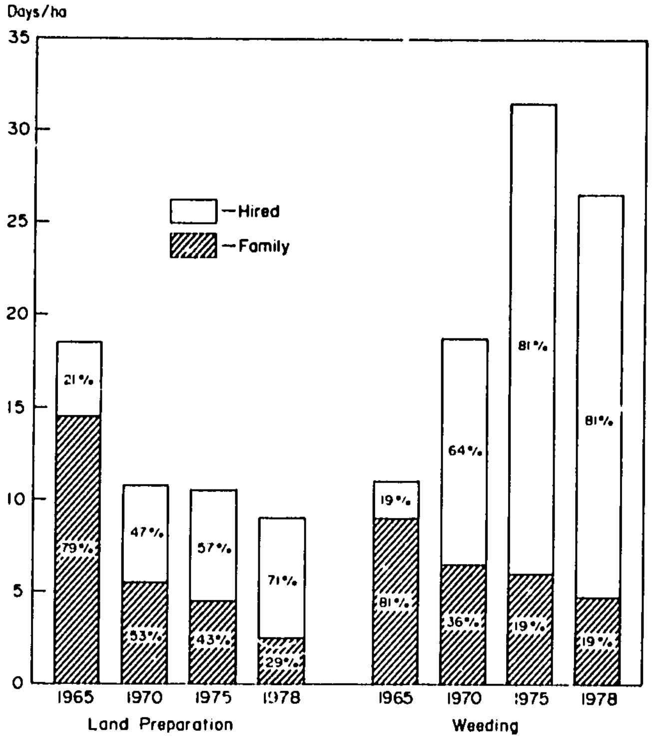

Fig. 5. Changes in the composition of land preparation and weeding labor, 45 Laguna farmers, 1965-78.

Table 9 evaluates each of the main operations according to these criteria. It is clear that harvesting, threshing, and transplanting always require hired labor. With the MV technology weeding is added. Because the MV technology requires hired labor for more operations, we hypothesized that as technology changes, *hired operations* become more important than *family operations* in increasing output.

A Cobb-Douglas production function was used to test the above hypothesis. A production function specifies to what extent each input, such as land, labor, and capital, contributes towards increasing output. Our objective in estimating a production function is to see if the contribution of labor used in hired operations has increased relative to that in family operations. This could be one factor explaining the increase in the use of hired labor.

Let the farm production function be represented by

$$Y_{it} = B_0 \cdot L_{H_{it}}^{\beta 1} \cdot L_{F_{jt}}^{\beta 2} \cdot X_{3_{it}}^{\beta 3} \cdot \ldots . X_{K_{jt}}^{\beta K} \cdot E_{it} \quad (1)$$

where

Y = paddy (kg) produced on the farm,

L_H = labor input (8-h work days) for operations that require hired labor,

L_F = labor input (8-h work days) for operations that do not require hired labor,

X_3 ... X_K = other conventional inputs, e.g. capital stock, expenditure on chemicals and fertilizers,

E = error term: unexplained variations in the data,

i = 1 ... n, where n = sample size,

t = 1, 2, where 1 refers to the old technology and 2 refers to the new technology.

The B_js are the coefficients to be estimated.

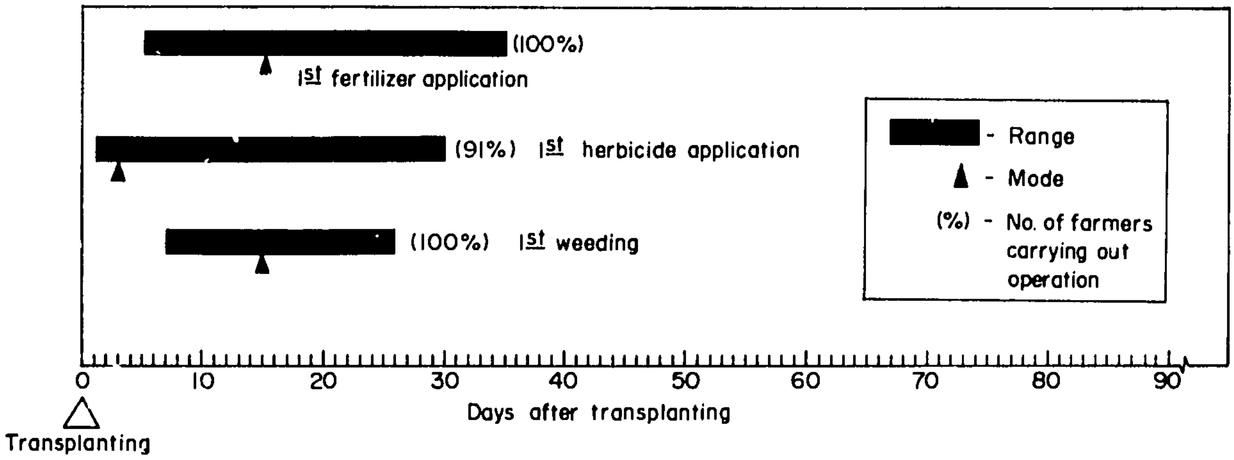

Fig. 6. Timing and frequency of operations for 45 Laguna farmers, 1978.

Table 9. Labor requirements vs family size, Laguna, Philippines, 1965 and 1978.

Operations	Labor requirements (days/farm)		Time span for completing (days/farm)	Total number of laborers required[a]		Index of workers vs available family members[b]	
	1965	1978	1978	1965	1978	1965	1978
Land preparation	44.2	21.1	9.3 (23.5)[c]	1.9	2.3	73	76.7
Repair and cleaning of dikes	9.7	11.9	6.7	1.4	1.8	54	60.0
Transplanting	22.7	23.1	0.9	25.2	25.7	504[d]	443[d]
Weeding	25.5	61.2	5.6	4.6	10.9	92	188[d]
Fertilizing and spraying	2.1	5.9	2.3	0.9	2.6	35	87
Harvesting and threshing and postharvest activities	82.3	63.9	3.9	21.1	16.4	422[d]	282[d]

[a]Col. 2/Col. 3 (for land preparation 1965, figure for unmechanized farmers is used). [b]Col. 4/family members 10 years old and above for transplanting, weeding, harvesting. Col. 4/male family members for other operations. [c]Unmechanized farmers. [d]Operations requiring hired labor.

Table 10. Average number of children per household, Laguna, Philippines, 1965 and 1978.

Family members	1965	1978
1. Males 18 years old and above	0.7	0.9
2. Males 10 to 17	0.9	1.1
3. Total males 10 and above (1 + 2)	1.6	2.0
4. Females 18 and above	0.6	0.8
5. Females 10 to 17	0.8	1.0
6. Total females 10 and above (4 + 5)	1.4	1.8
7. Total children 10 and above (3 + 6)	3.0	3.8
8. Children below 10	2.2	1.5
9. Total number of children living in family house (7 + 8)	5.2	5.3
10. Dependency ratio (A) (children below 10/family members 10 and above)	.44	.26
11. Dependency ratio (B) (children below 18/family members 18 and above)	1.18	0.97

In the Cobb-Douglas production function, the B_js are the production elasticities. The production elasticity of each input specifies the change in output resulting from a 1% increase in the use of that input, all other inputs being held constant.

Our objective is to see how the B_js change in response to technical progress. This can be done by

- estimating a separate production function for each type of technology as in Equation 1. This assumes that the variance of the error term differs between the two sets of data or
- pooling the data from both types of technology and allowing for the intercept and slopes of all inputs to change, by the inclusion of suitable dummy variables, as follows:

$$\text{Log } Y_{it} = \text{Log } B_0 + B_1 \text{ Log } L_{Hit} + B_2 \text{ Log } L_{Fit} + B_3 \text{ Log } X_{3it} + \ldots B_k \text{ Log } X_{Kit} + C_0 \cdot Z_{it} + C_1 \text{ Log } (L_{Hit}) \cdot Z_{it} + C_2 \text{ Log } (L_{Fit}) \cdot Z_{it} + C_3 \text{ Log } (X_{3it}) \cdot Z_{it} + \ldots C_k \text{ Log } (X_{Kit}) \cdot Z_{it} + e_{it} \quad (2)$$

where

$Z_{it} = 1$ if $t = 1$

$= 0$ if otherwise

and the C_js are additional coefficients to be estimated.

The B_js and C_js can be interpreted as follows:

	New technology	Old technology
Intercept	B_0	$B_0 + C_0$
Elasticity of L_H	B_1	$B_1 + C_1$

	New technology	*Old technology*
Elasticity of L_F	B_2	$B_2 + C_2$
Elasticity of X_k	B_k	$B_k + C_k$

Equation 2 assumes that the variance of the error term is the same for all observations, irrespective of the type of technology. One advantage of Equation 2 is that a significant C_j indicates a statistically significant change in the production elasticity of input j.

Only the 1965 and 1975 data were used in estimating the production functions. We excluded 1970 because technology was at a transitional stage at that time and data were not complete. 1978 was excluded because of selective typhoon damage.

Data from 49 farmers were used to obtain the estimates in Table 11. In all other parts of the analysis, data pertaining to 45 farmers were used. The 4 extra farmers were excluded because only rice production data were available for them. Hired operations were transplanting, harvesting, and threshing in the pre-MV technology, and transplanting, harvesting, threshing, and weeding in the MV technology.

Because 97 and 91%, respectively, of the above operations were actually done by hired laborers, hired labor for all operations was taken to substitute for labor use in hired operations. Operator's labor in all operations substituted for labor use in family operations.

The other inputs were the conventional production function inputs:

Capital stock: current value of farmers' stock of tractors, carabao and other farm implements, deflated by a price index developed from sample carabao and tractor prices.

Chemical inputs: expenditure on fertilizer, herbicides, and insecticides, deflated by the wholesale price index for chemicals.

Farm size: planted area (all variables are in *per crop* terms).

Dependent variable: output: farmer's production of paddy

Column 1 of Table 11 gives the regression estimates obtained by running regression 2, i.e. by pooling 1965 to 1975 data. In columns 2 and 3, the production functions for the two technologies were estimated separately. As is to be expected, pooled and separate estimation gave identical regression coefficients (Rau and Miller)

Columns 2 and 3 of Table 11 show that the contribution of hired labor increased with technical progress. In the MV technology, coefficient of hired labor was significant at the 5% level. With the old technology it was not significantly different from zero. That means that a 1% increase in hired labor could increase output by .2% with the MV technology. With the old technology, it would not significantly affect output. Operator's labor moves in exactly the opposite direction. Its contribution declines as technology advances. With the old technology, a 1% increase in operator's labor could increase output by .12%. With the MV technology, operator's labor no longer makes a significant contribution.

In column 1 of Table 11 we see that although the production elasticity of hired labor increases with change in technology, the difference is not statistically significant (Col. 1: C_1). On the other hand, the fall in the production elasticity of operator's labor is significant at the 10% level (Col. 1: C_2). This supports the hypothesis that the relative contribution of hired operations vs family operations increases with change in technology. Farmers, therefore, use more hired labor relative to family labor.

The coefficient for capital in 1965 is negative, indicating excess capacity. This is plausible because 76% of the farmers owned carabaos in 1965. With an average farm of 2.3 ha, it is highly likely that carabaos were underutilized.

The nonsignificance of the coefficient for chemical inputs in 1975 is surprising. However, fertilizer was found significant when separated from other chemical inputs (Col. 4). The remaining chemical inputs (insecticide and herbicide) remained insignificant. A possible cause is that the greater part of insecticide application was made during periods of serious infestation, when yields tended to be depressed. In addition, farmers appeared to apply less than the recommended dosage of insecticide, which could destroy predators and increase insect population (Litsinger et al 1978).

OPERATOR'S LABOR

A breakdown of preharvest family labor by family member shows that the bulk of the decline in family labor can be attributed to a decrease in operator's labor. Operator's labor dropped from 24.7 days/ha in 1965 to 8.4 in 1978 -- nearly one-third its previous level (Table 12).

Table 13 shows the operator's working days by activity.

In 1965 the operator worked a total of 196 work days. Fifty percent were spent on manual tasks on his rice farm. In 1978 his working days dropped to 149. Much of this decrease can be attributed to a decrease in work on his rice farm, which now accounted for only 25% of the total working time. We also find a significant increase in the time spent on other crops and livestock. That can mostly be accounted for by the time spent on growing watermelon, a highly labor-intensive, but lucrative crop.

In 1965 the farmer spent 24% of his working days in nonfarm jobs. Those were mostly casual jobs, usually in construction, picked up during the growing season when the marginal product of farm work was low. In 1978 the picture changed. Nonfarm work took only 25 days in the year, because the farmer was no longer unoccupied during the growing season. He visited his farm regularly, at least 3 to 4 times a week, and sometimes daily, to monitor the crop. Typically, on each visit he toured the

Table 11. Cobb-Douglas production function estimating log of rice production per farm as a function of independent variables specified below. Laguna, Philippines, 1965 and 1975 wet seasons.

Independent variables	Least squares estimates of production functions			
	Col. 1 pooled data (1965 and 1975)	Col. 2 new technology 1975	Col. 3 old technology 1965	Col. 4 new technology - 1975 - with fertilizer disagregated
Production elasticities				
Operator's labor: B_2	0.007	.004	0.12*	0.008
Hired labor: B_1	0.2**	0.2**	0.15	0.2**
Capital stock: B_3	0.03**	0.03**	-0.09**	0.03**
Chemical inputs: B_4	-0.02	-0.02	0.21**	
Farm size: B_5	0.56**	0.59**	0.48**	0.53**
Intercept: B_0	1.57	1.55	1.22	1.46
Differences between new and old technology				
Intercept: C_0	-0.35			
Operator's labor: C_2	0.13*			
Hired labor: C_1	-0.06			
Capital stock: C_3	-0.12**			
Chemical inputs: C_4	0.24**			
Farm size: C_5	-0.11			
$\bar{R}^2$	0.59	0.54	0.52	0.55
Fertilizer				0.24*
Chemical inputs excluding fertilizer				-0.005

* Significant at 10% level. ** significant at 5% level.

Table 12. Preharvest family labor requirements by family member (days/ha), Laguna, Philippines, 1965-78.

Farming operations	Operator				Other family members				Total family labor			
	1965	1970	1975	1978	1965	1970	1975	1978	1965	1970	1975	1978
Land preparation	11.28	3.25	3.05	1.62	3.17	2.43	1.45	1.04	14.45	5.68	4.5	2.66
Weeding	6.55	3.61	2.79	2.06	2.44	3.06	3.13	2.74	8.99	6.67	5.92	4.8
Other preharvest operations	6.83	7.68	6.53	4.7	1.54	4.88	4.16	3.87	8.37	12.56	10.69	8.57
Total preharvest operations	24.66	14.54	12.37	8.38	7.15	10.37	8.74	7.65	31.81	24.91	21.11	16.03

entire paddy field scrutinizing the crop for evidence of insects, rats, disease, and moisture inadequacy. He noted the exact stage of crop development to determine the correct timing for the various operations. He also spent considerable amounts of time visiting the Rural Bank, meeting with extension agents, and obtaining adequate supplies of fertilizer and chemicals. He hired more labor and equipment, which also required a substantial time input. These activities are defined as *farm management*. In 1978 management and supervision of hired labor took 34 days in the year. Although these activities did not take many days, they were spread fairly evenly throughout the cropping season. Also, the time required per day was highly unpredictable and depended on crop condition. The farmer was, therefore, tied to his farm and unable to look for outside jobs.

Data on management time for 1965 were not available. Farmers claimed the old technology was far simpler and did not require a significant input of management time. If we accept this contention, the number of working days in 1978 (including management) increases to 182, which is not significantly different from that in 1965 (Table 13).

Table 13. Composition of operator's work days per year, Laguna, Philippines, 1965 and 1978.

Activities	Work days/year			
	1965		1978	
	No.	%	No.	%
Manual work on rice farm	97.8	50	37.8	25
Hired agricultural work	9.9	5	17.9	12
Nonfarm salaried	30.6	16	17.8	12
Nonfarm self-employed	16.4	8	7.5	5
Other crops or livestock	40.8	21	67.7	46
Total (excluding management)	195.5	100	148.7	100
Management and supervision	n/a		33.6	
Total including management	-		182.3	

Production functions incorporating management

This section tests for increases in the marginal productivity of managerial ability after the introduction of the MV technology.

Theoretically the management component can be integrated into the production function by fitting the following regression (variables in logs), using pooled data from the MV and old technologies:

$$Y_i = B_0 + B_1 X_{1i} + \ldots B_5 X_{5i} + CM_i + F_0 Z_i + F_1 X_{1i} Z_i + \ldots F_5 X_{5i} Z_i + C^* M_i Z_i + e_i \qquad (3)$$

where

Y_i = paddy (kg) produced on the farm,

X_1 = labor (8-h work days) per farm,

X_2 = present value of capital stock,

X_3 = expenditure on fertilizer, herbicides, and insecticides,

X_4 = area planted to rice (all variables are on a per-crop basis),

X_5 = substitute for irrigation quality. Each municipality was ranked according to quality of irrigation. Calamba, which has continuous water, was assumed to have the best irrigation. Biñan, which suffers from tight water-scheduling, was considered the worst. Cabuyao, where irrigation is by private pumps, was given an intermediate rank.

M_i = an index of each farmer's managerial ability,

Z = 1 if the observation pertains to the old technology (1965), 0 if otherwise.

The B_is are the production elasticities under the MV technology. The F_js and C^* are the differences in production elasticities between the MV and old technologies. C is the production elasticity of management. It quantifies the percentage change in output resulting from a 1% improvement in managerial ability.

Because empirically, no observations on M_i are available, a method for estimating an index of managerial ability is developed below.

If we assume profit maximization and perfect markets, there should be no variation in the quantity of inputs used by different farmers. If we accept that managerial ability is responsible for the variation found in input use among farmers, a measure of management quality can be obtained by introducing farm-specific dummy variables into the production function.

With Mundlak's methodology (Mundlak 1961), the following production function (with variables in logs) can be estimated:

$$Y_i = B_0 + B_1 X_{1i} + \ldots B_5 X_{5i} + A_1 V_{1i} + \ldots A_{n-1} V_{n-1,i} + e_i \ldots\ldots\ldots\ldots \qquad (4)$$

where

n = number of farmers in the sample,

$V_1 \ldots V_{n-1}$ = farm-specific dummy variables such that

V_{ij} = 1 if 1 = j
0 if otherwise.

The rest of the notation is the same as in Equation 3.

The procedure requires two observations for each farmer to ensure that the number of observations exceeds the parameters to be estimated. The functional form of the production function and the quality of management are assumed to be the same for the two data sets.

$A_1 \ldots A_{n-1}$ provide estimates of each farm's intercept. Under the assumption that management accounts for individual variations in inputs, they provide an index of each farmer's managerial abilities, multiplied by a constant (c): the production elasticity of management. Computing management as a residual is equivalent to minimizing the residual sum of squares, in the analysis of covariance, with respect to $A_i = CM_i$, where M_i is the index of managerial ability. Best, unbiased estimates also require that A_i be normalized. Because management is measured in arbitrary units, neither the multiplication by a constant nor the normalization affects the management index.

On the assumption of constant returns to scale, the production elasticity of management (c) can be computed as

$$C = 1 - \sum_{j=1}^{5} B_j \quad \ldots\ldots (5)$$

An estimate of m_i of M_i, the management index can then be calculated by

$$M_i = \frac{A_i}{c} \quad \ldots\ldots (6)$$

Two sets of data pertaining to the MV technology (1975 and 1978) were subjected to the test for equivalence of regressions. The Appendix shows that it is not possible to reject the null hypothesis that the parameters of the production functions are identical for both data sets.

A production function excluding the farm-specific dummies ($A_1V_{1i} \ldots A_{n-1}V_{n-1,i}$) but otherwise identical to Equation 4 was then fitted to the two data sets. The sum of the elasticities (0.915) given in Table 14 shows that the assumption of constant returns to scale is fairly well-supported by the data.

Equation 4, including the farm-specific dummies, was then estimated, using both sets of the MV technology data. The results, given in Table 14, col. 1, show that the production elasticity of management computed as in Equation 5 is 0.34. A 1% improvement in managerial ability can be expected to increase output by 0.34%, with MV technology.

Table 14. Cobb-Douglas production function incorporating management, for estimating log of rice production per farm as a function of independent variables specified below.

Independent variables	Least squares estimates of production functions: New technology 1975 and 1978 (Col. 1)	Pooled data 1965, 1975, 1978 (Col. 2)	1975 and 1978 excluding management (Col. 3)
Production elasticities			
Labor: B_1	0.07	0.09	-0.03
Capital: B_2	0.01	0.01*	.005
Chemical inputs: B_3	-0.02	-0.02	.04
Farm size: B_4	0.54**	0.48**	0.84**
Irrigation quality: B_5	0.06**	0.05**	0.06**
Sum of elasticities (excluding management)	0.66		0.915
Intercept: B_0	1.73	-0.06	1.80
Management (C)	0.34[a]	0.35**	
Differences between new and old technology			
Intercept: F_0		0.32	
Labor: F_1		0.21	
Capital: F_2		-0.11**	
Chemicals: F_3		0.15**	
Farm size: F_4		-0.03	
Irrigation quality: F_5		-0.008	
Management: C*		-0.18**	
$\bar{R}^2$	0.65	0.78	0.59

[a]Computed as residual. ** Significant at 5% level, * significant at 10% level.

Equation 6 was then used to compute for the index of management ability (m_i). Once the estimate m_i of M_i was available, it was possible to test for changes in the production elasticity of management by fitting Equation 3. Pooled data from the two sets of MV technology and the old data set (1965) were used. The m_i values estimated from 4 and 6 were used for all three sets of data, on the assumption that the hierarchy of relative managerial abilities remains unchanged over time.

The production elasticity of management increased from 0.17 in the old technology to 0.35 in the new technology. The significant coefficient of C^* shows that this change was statistically significant at the 5% level.

Consequently the farmer should spend more time on farm management, at the expense of unskilled farm tasks, for which adequate replacements can easily be hired.

A word of caution is necessary at this point. To the extent that the production function is not completely specified, our estimated production elasticity of management captures the effect of not only management, but other omitted farm-specific factors as well. We cannot rule out the possibility that the productivity of some of these other factors may have increased with the change in technology. To the extent that this is true, the increase in the production elasticity of management will have been overestimated.

LABOR SUPPLY OF WIVES AND CHILDREN

Wives and children have never contributed significantly to farm work. The total number of days worked remained virtually unchanged at around 7 days/ha per crop (Table 12). Of these, the bulk of work (76%) was by males. Few daughters took part in farm work (Table 15). Wives appeared to participate more frequently, but the days worked per wife were obviously negligible.

Within the males, 61% of the work was by those 18 years old and above. Eighty percent of the younger sons were students and helped only on weekends and vacations.

In 1965 roughly half of all males above 18 helped on the family farm. One would have expected the participation rate to increase in 1978, to offset the decline in operator's labor. Participation, however, remained virtually unchanged. The cause lies in the dramatic increase in the earnings forgone by using an adult son on the farm (Table 16). In 1965 sons who did not participate in farm work were earning an average of ₱540 over the year. By 1978 this had increased by two and a half times, in real terms. This can be attributed to the increasing availability of full-time factory work. On the other hand, the work days available on the farm per adult male family member had dropped from 1?7 to 108 days/year /calculated by taking total preharvest work days (excluding transplanting, which was always hired), and deflating by number of adult males/. The agricultural wage had also dropped in real terms. As a result, the imputed earnings of farm work had decreased to 73% of its former value in real terms. Consequently, in net terms, it was more profitable for a son to work in a nonfarm capacity. Table 15 shows that in 1978, 60% of the sons and 53% of the daughters 18 years old and above were working in full-time salaried nonfarm jobs, mainly in factories.

CHANGES IN FARM FAMILY INCOMES

Table 17 and Figure 7 show an increase in annual income from all sources by 53% (real terms) between 1965 and 1978. Some of this increase came from rice farming but the bulk can be attributed to salaried nonfarm jobs and nonlabor sources of income (rents, interests, etc.). The drop in real earnings from other crops and livestock may appear surprising. Two factors accounted for the drop.

- In 1965 several farmers had share-tenancy rights to sugarcane land, which had been converted to other uses by 1978.
- Cultivation of watermelon was still in an experimental stage and several farmers reported crop failures and consequent negative returns from this activity.

As a result of increases in real income farmers have moved up to a higher rung on the agricultural ladder.

Table 15. Participation in income-generating activities and schooling. Laguna, Philippines, 1965 and 1978.

	Activities							
	Rice farming		Nonfarm self-employed		Nonfarm salaried		Schooling	
	1965	1978	1965	1978	1965	1978	1965	1978
Children (%)								
Males 18 years old and above	52	52	3	5	23	60	6	27
Males 10-17	24	54	0	5	2	6	71	80
Females 18 and above	7	8	14	25	28	53	21	13
Females 10-17	6	20	0	9	3	16	67	84
Wives (%)	30	41	16	38	5	14	-	-

Table 16. Average annual earnings in nonfarm occupations vs imputed earnings from farm work (per son 18 years old and above). Laguna, Philippines, 1965 and 1978.

Item	1965	1978	Index vs 1965
1. Days worked per annum by those not participating in farm work	117	352	301
2. Earnings/day (₱)	4.6	15.25	85[a]
3. Annual earnings from nonfarm work (1 x 2) (₱)	540	5370	255[a]
4. Days of work available on farm/adult male family member	137	108	79
5. Agricultural wage (₱)	3.5	12.6	93[a]
6. Imputed earnings from farm work (4 x 5) (₱)	480	1361	73[a]
7. Difference between nonfarm and farm earnings (3 - 6) (₱)	60	4009	1713[a]

[a]Real values (deflated by Consumer Price Index outside Manila). Sources: IRRI and PCARR 1976, *1965 to 1975 Data series on rice statistics, Philippines*; NEDA National Census and Statistics Office 1978 (unpublished mimeo).

Table 17. Average annual income by source. Laguna, Philippines, 1965 and 1978.

Source	Current income 1965 ₱	%	1978[a] ₱	%	Index of real income[b] vs 1965
Rice farming[c]	1,326	45	7,650	43	148
Hired agricultural work	72	2	436	2.5	156
Nonfarm salaried	539	18	4,168	24	198
Nonfarm self-employed	493	17	1,504	9	78
Other crops/ livestock	460	16	1,309	7.5	73
Nonlabor income	60	2	2,483	14	1,062
Total	2.950	100	17,550	100	153

[a]There was some typhoon damage in 1978. The contribution of rice farming income may be higher in normal years. [b]Deflated by Consumer Price Index outside Manila. [c]Net of paid-out costs. Sources: IRRI and PCARR 1976, *1965 to 1975 Data series on rice statistics, Philippines*; NEDA National Census and Statistics Office 1978 (unpublished mimeo).

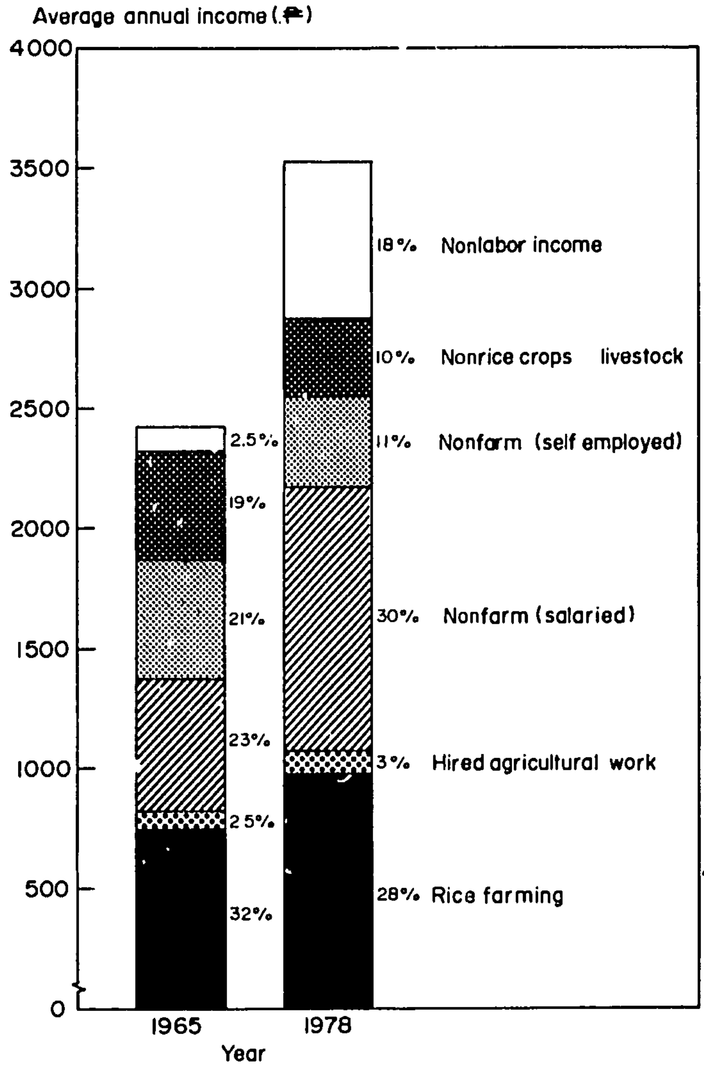

Fig. 7. Average annual farm income by source (49 rice farmers). Deflated by Consumer Price Index (CPI) outside Manila.

The Laguna farmer of 1978 is more of a farm manager than a tiller of the soil. He has the capacity to hire laborers and is possibly less inclined to do arduous tasks on his rice farm.

HISTORICAL PERSPECTIVE

The switch from family labor to hired labor and the change from labor-intensive rice production to labor-saving methods are strikingly similar to changes that took place in Japan and Taiwan after technical progress in agriculture. After the introduction of the Ponlai varieties in Taiwan in the 1930s, total labor input increased up to 1961 (Fig. 8). From 1967, labor began to be replaced by machinery. At the same time, family labor declined and the majority of farm tasks were done by hired labor (Barker and Cordova 1976). The main difference between the Taiwan and Laguna cases is the time span. In Taiwan the changes took place over 40 years; in Laguna they were compressed into less than 15 years.

One hypothesis about this difference in time span is that in Taiwan agricultural progress took place in the 1930s, when industry was still undeveloped. It was not until the 1960s that labor demand in industry began to put upward pressure on the agricultural wage. Subsequently, farmers adopted labor-saving practices, and farm family members moved out to more lucrative industrial jobs. In Laguna, industrialization followed close on the heels on technical change in agriculture. The whole process has, therefore, been telescoped into a shorter period.

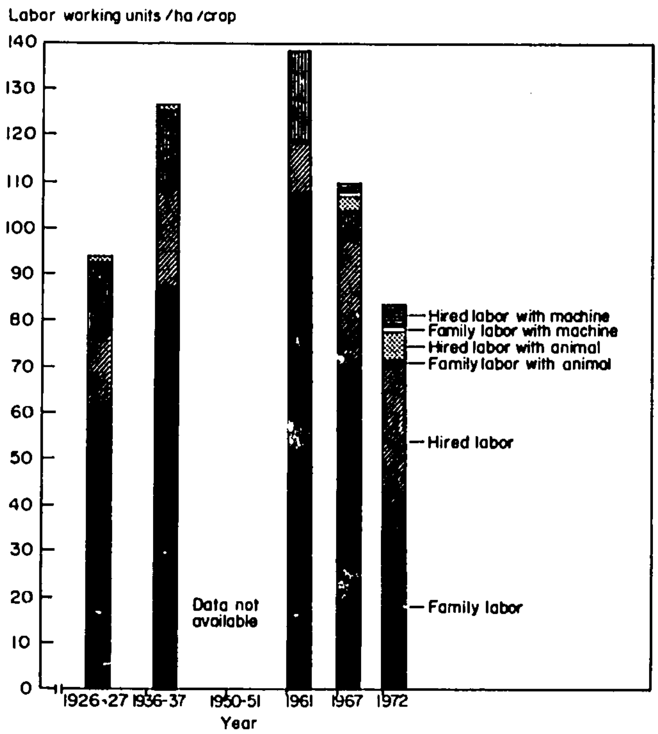

Fig. 8. Historical comparison of labor working units used per hectare, Central Taiwan, 1926-72. Source: Barker and Cordova 1976.

CONCLUSIONS AND IMPLICATIONS

Our main findings are:

1. Total labor use

   Until 1970 crop care activities required by the MV technology were met by an increase in labor. After 1975 chemicals and machinery began to replace labor. This change from labor-intensive to labor-saving practices reflects the farmer's adjustment to changing factor price ratios.

2. Hired labor vs family labor

   Family labor has been increasingly replaced by hired labor because:

   - With the MV technology, operations that require hired labor contribute more toward increasing rice production than operations handled by the family alone.
   - The productivity of management time has gone up.
   - The cropping pattern has been diversified to include watermelon, a highly labor-intensive but profitable crop.
   - The greater availability of factory work has increased earnings forgone by using family labor on the farm.
   - Increasing family incomes has increased the farmers' capacity to pay for hired labor.

3. Historical perspective

   The changes in labor use, following technical change, are a telescoped version of the Japanese/Taiwanese experience in structural transformation.

As pointed out earlier, the study area, because of its proximity to Manila, is atypical. It is interesting, not as a microcosm of the Philippines, but as a preview of possible future developments when industrialization and technical progress spread to other areas of the country. With this limitation in mind, the implications of our findings are:

1. They provide further support for the basic rationality of the farmer, as evidenced by his sensitive response to changing factor price ratios.

2. More importantly, for policy implications, they show that the new rice technology, per se, cannot be relied upon to provide continuing labor absorption in agriculture. The extent of labor absorption is importantly dependent on prevailing factor price ratios.

3. If land reform was instituted to *give land to the tiller*, it has failed. Prosperous farmers are no longer tillers of the soil, they can better be described as farm managers. However, if the ultimate objective of land reform was to improve living standards of the rural population, it appears to be succeeding. Farmers are richer and as they and their families withdraw from farm work, employment opportunities for those further down the agricultural ladder -- the landless laborers -- increase.

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APPENDIX

Test for equivalence of regressions (Rau and Miller)

Let the production functions for 1975 and 1978 be represented, respectively, by Equations 1 and 2.

$$\text{Log } Y_{it} = \log B_0 + B_1 \log L_{it} + B_2 \text{ Log } X_{2it} + \ldots B_4 \log X_{4it} + e_{it} \ldots \quad (1)$$

$$\text{and Log } Y_{it'} = \log B_0^* + B_1^* \log L_{it'} + B_2^* \text{ Log } X_{2it'} + \ldots B_4^* \text{ Log } X_{4it'} + e'_{it'} \ldots \quad (2)$$

where

Y = farm rice production,

L = days of labor used on farm,

X_2 = current value of capital stock (₱),

X_3 = expenditure on chemical inputs (₱),

X_4 = area planted to rice (ha),

e = error term.

The B_js and B_k^*s are the production elasticities. t and t' distinguish the two data sets.

The null hypothesis is that all parameters for 1975 and 1978 are the same.

i.e. $H_N : B_i = B_i^*$ for all i

$H_A : H_N$ is false.

The residual sum of squares obtained after running Equations 1 and 2 are summed to give $RSS\ (H_A)$. $RSS\ (H_N)$ is obtained by pooling the data over the 2 years and running either 1 or 2.

	1975	*1978*	*1975 and 1978 pooled*
Residual sum of squares	0.83	0.98	1.85
Sample size	49	47	96

$$F = \frac{[RSS\ (H_N) - RSS\ (H_A)]\ /n}{RSS\ (H_A)\ /\ (T - K)}$$

where

n and $(T\text{-}K)$ are degrees of freedom (df)

$n = df$ of $RSS\ (H_N) - df$ of $RSS\ (H_A)$

$= [96-(44 + 42) = 5]$

$T\text{-}K = 96-5 = 91.$

In our case, $F = \frac{(1.85 - 1.81)/5}{1.81/91}$

$= \frac{.008}{.02} = 0.4$

which is not significant. Therefore we cannot reject the null hypothesis that $B_i = B_i^*$ for all i.

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