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THE CONSEQUENCES OF SMALL RICE FARM MECHANIZATION PROJECT

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EMPLOYMENT AND AGRICULTURAL MECHANIZATION: AN ANALYSIS OF SURVEY RESULTS

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by

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EMPLOYMENT AND AGRICULTURAL MECHANIZATION: AN ANALYSIS OF SURVEY RESULTS*

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INTRODUCTION

In the debate and controversy over the effects of mechanization, much attention has been focussed on the degree of substitution between capital and labor. In labor surplus economies, the social (and personal) costs of labor displacement may be enormous if alternative employment opportunities do not readily exist.

However, although there is some evidence that machines directly replace labor the benefits or costs will depend on the local context and circumstances. Further, mechanization is nearly always associated with the adoption of other yield augmenting inputs and with changes in cultural practices so that the gross effect on employment may offset the net effects of any capital labor substitution.

Quantitative data on the degree of labor displacement is not readily available and this has hindered the debate. Often, data is limited or site specific and therefore not readily generalizable. It is extremely difficult to partition changes in labor input over time and across different farm types into separate components such as labor-machinery substitutability and the yield effects associated with

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different input levels and different techniques of production. The consequences of mechanization study aimed to collect data at four sites in South East Asia, where mechanization was in the process of becoming established in order to provide the sort of quantitative data which is required for both research and policy intervention.

In the Philippines, the area chosen for the survey was Nueva Ecija province in Central Luzon, an area in which it was possible to find a sufficiently large numbers of tractor farms in both rainfed and irrigated areas.

The survey, which was carried out in 1979/80 provides cross-section data from selected households in eight villages, four from the predominantly rainfed Guimba district and the remaining four from Cabanatuan, an irrigated district relatively close to Cabanatuan City. This survey site therefore provides opportunities for non-farm work which are not available in Guimba. The sample design used a stratified random sampling procedure to ensure a sufficiently large number of mechanized farms were included in the survey.

In collecting the data, FAO's Farm Management and Data Collection and Analysis system (FMDCAS) was used together with supplementary questionnaires providing more detailed information on machine use. In addition, historical information about the reasons for machine adoption and subsequent changes in cropping patterns resulting from the adoption of mechanical land preparation technique was assembled.

Cross sectional data has certain limitations - in particular the researcher is forced to infer the 'before' and 'after' effects from 'with' and 'without' data. However, since the historical setting and

exogenous forces of the 'before' situation cannot be recreated, it is quite likely that this will differ from the 'after' situation in some way but such differences will not be reflected in the 'with' and 'without' data. The following analysis is limited by the restrictions of cross-sectional data and merely involves looking at and accounting for differences in the utilization of labor for rice production on farms with alternative land preparation techniques at one point in time only.

CLASSIFICATION SCHEME

Households were classified on the basis of both the land preparation technique employed and on the type of irrigation. Classification was on the basis of largest parcel. There were three irrigation classes - rainfed, pump irrigated and gravity irrigated.

In order to capture the shifts in mechanization classes between seasons, the mechanization groups were based on land preparation techniques in both the wet and dry seasons. Non-mechanized farms used draft animals for land preparation in both seasons, while fully-mechanized farms used tractors and/or power tillers in both seasons. The remaining farms who used a combination of animal and mechanical power were classified as partially mechanized.

Table 1 shows the number of sample households in each class. However, since the sampling design employed was stratified, it is useful to consider a conceptual population based on the relationship between the sample size and the census population. This is shown in Table 2.

Roughly half of this estimated population are in the rainfed category and nearly three quarter of this group are non-mechanized. The

rest are partially mechanized and employ animals for land preparation during at least one season.

Within the gravity irrigated group, only 2% of the households are non-mechanized, indicating a strong correlation between irrigation and mechanization. This confounds the analysis of the output effects of mechanization since irrigation is known to have a major effect on yield.

This study therefore focuses on the differences between non-mechanized and partially mechanized farms in the rainfed areas and between partially mechanized and fully mechanized farms in the gravity-irrigated class.

BACKGROUND

Nueva Ecija is a predominantly rice growing area and most of the farmers grew rice in both the wet and dry seasons. Nearly all farmers used modern varieties in both seasons and transplanting was everywhere preferred to broadcasting.

There was little difference in the age or educational backgrounds of the farmers although the farmers in the gravity irrigated areas were slightly older on average (Table 5).

Farm size, owned land plus net rented land, was larger in the gravity irrigated area when compared to the rainfed area. Within both irrigation groups the more mechanized farms had larger farm sizes.

However, the percentage of managed land which was owned was much less on the gravity irrigated farms and was particularly low for the

fully mechanized group. This group had the lowest level of owned land, when compared to all the other groups.

LABOR UTILIZATION BY ACTIVITY

Total per hectare labor use for wet season rice cultivation in general is higher on rainfed than irrigated farms and is associated with the greater use of mechanization on irrigated farms (Table 6).

With n the rainfed class, non-mechanized farms use 15% more labor than partially mechanized ones. A large proportion of this additional labor is used in land preparation with the non-mechanized group using roughly 50% more labor than the partially mechanized groupfor this activity.

The other differences within the rainfed class were small. The lower per hectare harvesting and threshing times for the partially mechanized class reflect a greater use of mechanical threshers.

There were no significant differences between overall labor use within the irrigated class. Partially mechanized farms used about 40% more labor for land preparation but this was a relatively small difference when compared with differences across the rainfed/irrigation classifications. Although yields were considerably higher for irrigated farmers, harvesting labor was at about the same level as for rainfed farmers. Again, the greater use of mechanical threshers within the irrigated area is partly responsible for this difference in labor use.

For the dry season, a comparison between rainfed and irrigated farms is not possible since the few rainfed farms who cultivate do so on an extremely small area in the dry season (Table 7). Within the

irrigated class, the mechanized farms used 15% less labor than partially mechanized farms. Most of this extra labour was utilized in harvesting and threshing. Since yields were only marginally higher this is probably due to higher usage of mechanical threshers among the fully mechanized land preparation farms.

This suggests that, most of the labor displacement in the irrigated areas has already occurred and that further mechanization in these areas will not displace much more labor. Labor saved by mechanical land preparation practices are redeployed in greater transplanting and other crop care activities. However, given the process of switching between broadcasting and transplanting and also between manual and mechanical threshing that was occuring in the survey area in 1979/80 it cannot be implied that this conclusion either holds today or is generalizable to other sites. The direct effect remains of a reduction of land preparation labor with mechanization. Given the association between farms with mechanical land preparation and mechanical threshing, it is likely that the overall effects of increased yields associated with modern cultural practices have not led to greatly increased demand for labor. In the rainfed areas, increased mechanization of land preparation is likely to cause more significant displacement since the present level of mechanization is much lower.

REGRESSION ANALYSIS ON TOTAL LABOR UTILIZATION

A linear regression was estimated for total per hectare labor use for both irrigated and rainfed farms (Table 8). Area planted was included as a proxy for management effects associated with the

organization of a large numbers of laborers. The mechanization dummy, for the rainfed farms, was not significant, although it had the expected negative sign. The area effect was highly significant, suggesting a scale/size effect at work. Without mechanization, larger farms were applying less labor.

Within the irrigated farm group the mechanization dummies were very significant and negative showing that labor displacement was correlated with mechanized farms. However, the area variable was insignificant.

Similar results hold for a linear regression upon land preparation mandays (Table 9). Here area is negative and significant for both rainfed and irrigated households showing the inverse relationship between labor use and planted area. The mechanization dummies are also negative and significant but the difference between the partially and fully mechanized dummies for irrigated farms is not very large. This suggests that mechanization of land preparation is labor displacing but, further investigation is required to ascertain why precisely the area parameter is negative. Is this due to profit maximizing behaviour such as income-satisficing by the larger farmers or to some underlying scale economy involving labor use? In any case cautious interpretation of the statistical results in both tables must be used for the equations presented have low explanatory power. Only approximately 20% of the variation in labor use/ha is explained by the specific equations.

Tables 10 and 11 present similar results for the dry season. Despite the small absolute value for area planted, the area coefficient is negative and significant for rainfed farms.

HIRED LABOR UTILIZATION BY ACTIVITY

Although mechanization may lead to a reduction in total labor use, this does not necessarily apply to the demand for hired labor. Table 12 shows that the percentage of hired labor is considerably higher on irrigated farms than on rainfed farms.

This is also higher in absolute terms and may be due to the substitution of machines for family as opposed to hired labor. Machines enable family labor to work in the non-farm sector and although data is not available to quantify this demand the largely irrigated villages of Cabanatuan are situated relatively close to Cabanatuan City, providing a source of urban employment.

The percentage of hired labor used by mechanized farms in the irrigated area is, in general, higher for all activities.

Within the rainfed class, partially mechanized farms use more hired labor for land preparation but overall, a smaller percentage of the labor used is hired. Further, these farms hire in less labor per hectare in absolute terms.

The dry season figures are comparable (Table 13), the major difference being the higher amount of hired labor for land preparation used on fully mechanized irrigated farms.

CONCLUSION

This preliminary analysis suggests that mechanization results in reduced total labor use per hectare of cultivated land However, the demand for hired labor appears to be higher on mechanized farms and it would appear that any displacement effects of mechanization affect family labor rather than wage labor. Further mechanization of land preparation activities in irrigated areas is unlikely to displace much more labor, given the present level of mechanization in those areas. In the rainfed areas, increased tractorization is likely to cause substantial labor displacement. Mechanization, in the area, frees family labor to manage larger farms and/or increase their consumption of leisures. Mechanized farms appear to hire a larger share of the total farm labor.

Table 1. Distribution of sample households among classification groups, wet season, 1979.

Irrigation class	Mechanization level			
	Non-mech.	Partial mech.	Full mech.	All
Rainfed	77	46	1	124
Pump irrigated	39	15	0	54
Gravity irrigated	7	79	54	140
All	123	140	55	318

Table 2. Distribution (%) of estimated population among classification groups, wet season, 1979.

Irrigation class	Mechanization level			
	Non-mech.	Partial mech.	Full mech.	All
Rainfed	31	14	0	46
Pump irrigated	8	4	0	12
Gravity irrigated	2	21	18	42
All	41	40	19	100

Source: Consequences of Small Rice Farm Mechanization.

Table 3. Distribution of sample households among classification group, dry season, 1979/80.

Irrigation class	Mechanization level			
	Non-mech.	Partial mech.	Full mech.	All
Rainfed	19	15	1	35
Pump irrigated	25	12	0	37
Gravity irrigated	7	78	54	137
All	51	105	55	211

Table 4. Distribution (%) of estimated population among classification groups, dry season 1979/80.

Irrigation class	Mechanization level			
	Non-mech.	Partial mech.	Full mech.	All
Rainfed	12	7	0	20
Pump irrigated	9	5	0	14
Gravity irrigated	3	34	30	66
All	24	46	30	100

Source: Consequences of Small Rice Farm Mechanization.

Table 5. Characteristics of farmer and farm holdings in selected villages, Guimba and Cabanatuan, Nueva Ecija, Philippines, wet season, 1979.

	Rainfed		Gravity irrigated	
	Non-mech.	Partial mech.	Partial mech.	Full mech.
Farmer's age (years)	43	44	46	47
Farmer's education (years)	4.6	5.0	4.7	4.2
Land managed (ha)	2.10	2.22	2.19	2.54
Percentage of managed land which is owned (%)	69	82	44	26
No. of draft animals per farm	1.07	0.79	0.89	0.16
No. of tractors per farm	0	0.02	0.47	0.70
Estimated population	276	128	190	163
Sample size	77	46	79	54

Source: Consequences of Small Rice Farm Mechanization.

Table 6. Average labor per hectare by crop activity for rice production in selected villages of Cabanatuan and Guimba, Nueva Ecija, Philippines, wet season 1979.

	Rainfed		Irrigated	
	Non-mechanized	Partially mechanized	Partially mechanized	Fully mechanized
	per hectare			
Land preparation	145	98	65	47
Seedbed preparation and planting	176	154	191	214
Total crop establishment	321	252	256	261
Fertilizing	6	6	9	9
Spraying	9	6	13	15
Weeding	15	18	5	2
Irrigation and drainage*	1	0	1	0
Total care and cultivation	31	30	28	26
Total pre-harvest	352	282	284	287
Harvesting/threshing/ other post-harvest	261	243	247	223
Total	607	528	536	511
Yield	1902	1826	3860	3803
% using threshers	40	48	42	56
% transplanting	95	93	94	98
Sample size	77	46	79	55
Estimated population	276	128	190	163

* Pre planting irrigation is included in land preparation.

Source: Consequences of Small Rice Farm Mechanization.

Table 7. Average labor hours per hectare by crop activity for rice production in selected villages of Cabanatuan and Guimba, Nueva Ecija, Philippines, dry season, 1980.

	Rainfed		Irrigated	
	Non-mechanized	Partially mechanized	Partially mechanized	Fully mechanized
	per hectare			
Land preparation	249	171	60	50
Seedbed preparation and planting	276	241	186	174
Total crop establishment	525	412	246	224
Fertilizing	8	12	11	12
Spraying	19	13	16	17
Weeding	6	5	0	0
Irrigation and drainage*	27	35	0	0
Total care and cultivation	60	65	27	30
Total pre-harvest	585	477	273	254
Harvesting/threshing/ other activities	387	288	222	176
Total	973	769	503	434
Yield	3426	2564	4469	4485
% using threshers				
% using transplanting				
Estimated population	66	41	188	163
Sample size	19	15	78	54

*Pre planting irrigation is included in land preparation.

Source: Consequences of Small Rice Farm Mechanization.

Table 8. Weighted estimated coefficients for total mandays per hectare for rainfed and gravity irrigated farms, for rice farm households in selected villages, Cabanatuan and Guimba, Nueva Ecija Province, Philippines, wet season 1979.

Explanatory variables	Weighted coefficients	
	Rainfed	Irrigated
Intercept	112.3 (19.2)	129.0 (8.7)
Area planted	-14.1 (-6.2)	- 1.38 (-0.6)
Dummy (fully mech.)		-59.1 (3.7)
Dummy (partially mech.)	-6.6 (1.1)	-43.2 (2.8)
R^2	0.25	0.12
F-value	(13.7)	(6.4)
N	124	139

Figures in parenthesis are t-statistics to test the hypothesis that population coefficient is zero.

Dependent variable is total mandays per hectare.

Source: Consequences of Small Rice Farm Mechanization.

Table 9. Weighted estimated co-efficients for land preparation mandays per hectare for rainfed and gravity irrigated farms. Rice farm households in selected villages of Cabanatuan and Guimba, Nueva Ecija, Philippines, wet season 1979.

Explanatory variables	Weighted coefficient	
	Rainfed	Irrigated
Intercept	21.1 (16.8)	19.4 (11.2)
Area planted	-2.7 (-5.5)	-0.6 (-2.1)
Dummy (fully mech.)		-11.6 (-6.3)
Dummy (partially mech.)	-2.6 (-2.0)	-9.3 (-5.1)
R^2	0.23	0.30
F-value	12.3	18.4
N	124	139

Figures in parenthesis are t-statistics to test the hypothesis that population coefficient is zero.

Dependent variable is total mandays for land preparation per hectare.

Source: Consequences of Small Rice Farm Mechanization.

Table 10. Weighted estimated coefficients for total mandays per hectare for rainfed and gravity irrigated farms in selected villages, Guimba and Cabanatuan, Nueva Ecija, Philippines, dry season, 1979/80.

Explanatory variables	Weighted coefficient	
	Rainfed	Gravity irrigation
Intercept	153.7 (8.04)	170.6 (9.04)
Area planted	-46.0 (-4.1)	-9.0 (-3.0)
Dummy (fully mech.)		-80.4 (-4.0)
Dummy (partial mech.)	-3.1 (-0.2)	-68.5 (-3.4)
R^2	0.38	0.20
F value	(6.23)	(11.15)
N	34	140

Figures in parenthesis are t-statistics to test the hypothesis that population coefficient is zero.

Dependent variable is total mandays per hectare.

Source: Consequences of Small Rice Farm Mechanization.

Table 11. Weighted estimated coefficients for land preparation mandays per hectare for rainfed and gravity irrigated farms in selected villages, Guimba and Cabanatuan districts, Nueva Ecija Province, Philippines, dry season 1979/80.

Explanatory variables	Weighted coefficients	
	Rainfed	Gravity irrigated
Intercept	29.4 (6.41)	30.1 (12.8)
Area planted	-9.2 (-3.4)	-0.5 (-1.4)
Dummy (fully mech.)		-22.4 (-8.9)
Dummy (partial mech.)	-1.3 (-0.2)	-20.4 (-8.2)
R^2	0.30	0.41
F value	(4.24)	(31.01)
N	34	140

Figures in parenthesis are t-statistics to test the hypothesis that population coefficient is zero.

Dependent variable is total mandays land preparation per hectare.

Source: Consequences of Small Rice Farm Mechanization.

Table 12. Percent contribution of hired labor to total per hectare labor requirement by activity, source, and farm type in selected villages of Cabanatuan and Guimba, Nueva Ecija, Philippines, wet season, 1979.

	Rainfed		Irrigated	
	Non-mechanized	Partially mechanized	Partially mechanized	Fully mechanized
	percentages			
Land preparation	35	50	27	26
Planting and seedbed preparation	87	74	92	96
Total crop establishment	67	64	77	87
Fertilizing	8	5	20	21
Spraying	1	8	21	20
Weeding	15	15	56	0
Irrigation	0	0	18	0
Other crop cultivation	0	13	20	25
Total care and cultivation	9	12	26	19
Total pre-harvest labor	62	58	70	81
Harvesting and processing	47	37	93	97
Drying	2	0	6	58
Other activities	34	37	75	62
Total post-harvest	46	37	88	92
Total	56	48	74	84
Sample size	77	46	79	55
Estimated population	276	128	190	165

Source: Consequences of Small Rice Farm Mechanization.

Table 13. Percent contribution of hired labour to total per hectare labor requirement by activity, source, and farm type, in selected villages of Cabanatuan and Guimba, Nueva Ecija, Philippines, dry season 1980.

	Rainfed		Irrigated	
	Non-mechanized	Partially mechanized	Partially mechanized	Fully mechanized
		percentages		
Land preparation	39	19	28	53
Seedbed preparation and planting	76	72	91	96
Total crop establishment	62	54	77	86
Fertilizing	2	7	27	31
Spraying	0	15	28	40
Weeding	0	0	0	0
Irrigation/drainage	0	0	0	0
Other care/ cultivation	0	0	29	34
Total care/ cultivation	2	4	28	34
Total preharvest labor	56	46	70	80
Harvesting/processing	79	60	94	58
Drying	0	0	0	0
Other activities	20	41	70	78
Total postharvest	75	59	84	68
Total	60	50	73	79
Sample size	19	15	78	54
Estimated population	66	41	188	163

Source: Consequences of Small Rice Farm Mechanization.