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MECHANIZATION OF SMALL RICE FARMS IN THE PHILIPPINES: SOME INCOME DISTRIBUTION ASPECTS

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MECHANIZATION OF SMALL RICE FARMS IN THE PHILIPPINES: SOME INCOME DISTRIBUTION ASPECTS*

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ABSTRACT

Considerable controversy exists about the desirability of farm mechanization in the Philippines. Survey evidence shows that the introduction of tractors has not directly resulted in yield and cropping intensity increases yet the employment displacement potential is great. Income shares are presented for different classifications of mechanized and irrigated farms and the effects of new technology on the welfare of landless laborer households are discussed.

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The desirability of agricultural mechanization in Asia can be questioned. One view is that development requires machine power to increase output and assist in the absorption of labor by permitting intensification of land use. Mechanization is the solution to overcoming labor bottlenecks which constrain cropping intensity which prevent labor absorption at other times of the year. Mechanization will thus increase output and employment by expanding the annual harvested area and from higher yields associated with deeper ploughing and timely cultivation methods. A counter view asserts that mechanization has no output effects and is socially undesirable since it merely represents a substitution of capital for labor resulting from distortions in factor price ratios caused by non-market forces and government intervention.[1] This paper explores these issues using Philippine evidence. Mechanization refers to power equipment used in land preparation, mainly tractors and power tillers (or two-wheel tractors), and also to mechanical threshers. The paper is not directly concerned with irrigation pump.

Agricultural mechanization in the Philippines commenced with introduction of four-wheel tractors into the sugarcane industry in the early 1960's. Imported power tillers were available by 1962 but widespread adoption only occurred between 1966-1968 following the First Central Bank: I.B.R.D. Rural Credit Project ($5m) signed in November 1965. Table 1 shows the increase in sales of machinery and there is evidence that the mechanization process was a credit driven one. Further C.B.:I.B.R.D. Rural Credit Projects were approved in 1969 ($12.5 m), 1974 ($22 m) and 1977 ($36.5 m). Devaluation of the peso reduced sales of increased sales of power tillers in 1970 by 28% and 48% respectively and increased sales of power tillers in 1972 were primarily a result of the invention of low-cost IRRI designs. Four wheel tractor sales improved between 1971-1974 because of favorable world prices for sugar which was, however, followed by the 1973 oil crisis. Peak sales for both tractors and tillers occurred in 1975 when an outbreak of foot and mouth disease severely reduced the carabao (water-buffalo) population.

Sales improved in 1977 following the release of funds from the Fourth C.B.:I.B.R.D. Rural Credit Project and there was also an increasing demand for mechanical threshers and driers. Since 1978 however sales of power tillers and tractors have declined. Increased costs, the second oil crisis in 1979 and a secular decline in sugar

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[1] C. C. David (1983) outlines some of the distortions; these include an overvalued exchange rate, tariffs and advanced sales taxes, negative real interest rates, credit programmes, minimum wages policies, etc.

prices have all contributed to this downward trend and with the peso devaluation in 1983 the agricultural machinery industry in the Philippines is at the crossroads.

Output Effects of Mechanization

Whether mechanization increases yields and cropping intensity is difficult to answer conclusively. Data are often inadequate and site specific and there are analytical difficulties in isolating the effects of mechanization from confounding influences of complementary inputs particularly irrigation and fertilizers. The Consequences of Mechanization Study collected cross sectional data in 1979/80 from selected households in eight villages in Nueva Ecija Province, Central Luzon, the Philippines, in both rainfed and irrigated areas. Households were classified by land preparation technique and type of irrigation used. Table 2 shows the number of households in each class.

Because of the cell sizes, the study focussed on differences between non-mechanized and partially mechanized farms in rainfed areas and between partially and fully mechanized farms in the gravity irrigated class. The basis for inclusion in mechanization classes was the land preparation technique used in both wet and dry seasons. Non-mechanized farms used draught animals in both seasons, fully mechanized farms tractor and/or power tillers in both seasons and the partially mechanized category used both animal and machine power. All farms used modern rice varieties, transplanted rather than broadcasted and average farm size was a little over two hectares.

Studies measuring the effects of mechanization on cropping intensity appeal to the timeliness issue but frequently the dominant variable is irrigation rather than power supply. High levels of cropping intensity are often achieved without tractors[2] although in rainfed Philippine environments like Iloilo Province, shorter turn-around times and earlier crop establishment can mean the difference between double and single-cropping. Mechanical threshers may play a part in reducing the turn-around period. Evidence from the Consequences Study on cropping intensity (the ratio of total land planted in both seasons to farm size) shows the importance of water availability. Cropping intensity in the gravity irrigated areas was closed to 2; in the rainfed areas it was only about 1.2 on both partially mechanized and non-mechanized farms. Regression analysis results are shown in Table 3.

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[2]See for example Lingard and Sri Bagyo (1983).

As expected the irrigation dummies are positive and significant while the mechanization dummies are positive, small and insignificant. Area managed was included to examine whether an inverse farm size effect existed. A significant negative coefficient was estimated. The function was estimated separately for rainfed and irrigated farms; small insignificant coefficients on the mechanization dummies were obtained but goodness of fit were low. Thus irrigation dominated cropping intensity effects with mechanized land-preparation playing only a minor supportive role.

Yield effects were significantly different between rainfed and irrigated groups with dry season yields higher than wet season yields. There were however no significant differences between mechanization classes within each irrigation group for the wet season and few rainfed farms cultivate in the dry season. Production function analysis was used to test whether mechanization had any effect on yield when differences in other inputs are taken into account. Results are shown in Table 4 for a Cobb-Douglas functional form using wet season data.

Fertilizer, pesticides and preharvest labor all had positive and significant effects as did the irrigation class dummies. However the mechanization dummies had small insignificant coefficients suggesting that mechanization had little effect on yield. Re-estimating the functions within rainfed and gravity strata separately made little difference. We can therefore conclude that, for our sample, in 1979/80 the major determinant of yield and cropping intensity appears to be irrigation. There is no discernible evidence of output effects directly attributable to mechanization.

Employment Effects of Mechanization

In the absence of increased output machinery adoption will shift earnings from one group to another. If a machine replaces labor then wages formerly paid to laborers will accrue to the owner of the machine and when machinery had no output effects, adoption simply redistributes income. It is important therefore to measure the degree of substitution between machines and labor. However it is difficult to partition changes in labor input over time and across different farm types into separate components since mechanization is often associated with adoption of additional yield augmenting inputs and changed cultural practices. Thus the observed gross effect on employment may outweigh the net effects of any capital-labor substitution. Inferring and measuring from cross-sectional sample data has limitations as one attempts to disentangle and decompose aggregate data into separate identifiable effects. 'With' and 'without' data was collected to infer the dynamic 'before' and 'after' effects yet forces of the 'before' situation cannot be re-created and some effects are not reflected in static 'with' and 'without' data.

Despite this, it is illuminating to examine labor utilization on farms with different land preparation methods at one point in time. Labor use figures for the farms of Table 2 are shown on Table 5.

Total per hectare labor use was higher on rainfed than irrigated farms and within the rainfed area non-mechanized farms used 15% more labor and 50% more land preparation labor per hectare than partially mechanized farms. Other differences within the rainfed class were small and there are few significant differences within the irrigated class between mechanization states. Irrigated farmers obtained considerably higher yields yet harvesting labor was similar to rainfed farmers partially due to their greater use of mechanical threshers. Although mechanization results in a reduction of land preparation labor, some additional labor is redeployed in seedbed preparation, transplanting and crop care activities which may contribute to higher yields. In the rainfed areas the potential displacement of labor by machines is great at the prevailing low leves of mechanization.

Turning to the breakdown of labor into family and hired categories, in both absolute and percentage terms, hired labor use is much greater in irrigated than rainfed farms. The substitution of machines for labor appears to be for family as opposed to hired labor. Machines release family labor to work in the non-farm sector since the irrigated villages are relatively close to Cabanatuan City, a source of urban employment. This phenomenon of family labor displacement was also noted by Ingard and Wicks for the Consequences Data Sites in West Java and South Sulawesi, Indonesia. One can speculate that machines enable family labor to escape the drudgery of farm work and still maintain their income position.

Table 6 presents results for land preparation mandays per hectare when regressed on farm size and mechanization dummies for both the rainfed and irrigated farms. The area coefficient is negative and significant for both rainfed and irrigated households as are the mechanization dummies but the difference between the partially and fully mechanized dummies is small. The overall fit of the equation is low; although mechanization of land preparation operations is clearly labor displacing satisfactory statistical and economic explanations have not been found for total employment relationships. Increased tractor use in the rainfed areas is however likely to result in substantial reductions in employment and in the absence of rising real wages should be discouraged.

Factor Shares and Mechanization

Income from rice production is distributed in two ways; to the factors of production (labor, land, capital and cash inputs) and then via the resource ownership pattern (hired labor, landlord, hired capital, cash inputs, farmer-operator) to the final distribution of

income. Data was aggregated to show average costs and returns from different rice production systems (Table 7). The average wage paid to hired labor was imputed to family labor, average rent imputed for owned land and appropriate imputations made for owned capital and seed.

In the wet season capital and labor costs represent the largest proportion of total costs for all farm groups. However in the dry season (not shown) capital and cash inputs form the largest proportion. Percentage earner shares are tabulated in Table 8.

The highest income share went to operators especially in the wet season ranging from 30 to 50%. However it was not significantly different with respect to irrigation or mechanization groups. Hired labor and landlords shares ranged from 17 to 22% and 3 to 13% respectively but again were not significantly different across irrigation and mechanization states. Hired capital's share (1 to 11%) was consistently higher on mechanized farms compared to non-mechanized ones. Cash inputs share showed significant differences only in the dry season being higher on pump irrigated and rainfed farms but no difference existed with respect to the degree of mechanization. Such preliminary analysis leads to little conclusive evidence on the income distribution debate.

Landless Laborers

Within the Philippines industrial expansion has been capital-intensive generating a low labor demand and, despite migration to the urban informal sector, a significant proportion of landless laborers remain in rural areas dependent on small rice farms for wage employment. Some 40% of the agricultural labor force falls in this category and they may soon account for up to 4 million people. Small farmers likewise depend on wages for continued existence of their peasant livelihood and recent advances in new rice technology have affected both labor use and shares.

Landless laborers are distinguished by their inaccessibility to land and complete dependence on farm work to earn an income. The common fiction is that they are plagued by problems of low income, hunger, morbidity, infant mortality, low educational attainment and little upward mobility. To test that view 47 landless laborer households were included in our survey and a supplementary study considered a further 64 landless laborers and 36 small farmers who hired out their labor. Landless laborer households comprise between 5 and 18% of total households in the 8 sample villages, average age of household head was 40 years with up to 4 years schooling and household size averaged 5.6 persons. Migration of a seasonal or permanent nature was minimal and, unlike farmers, they had little access to public agencies. Asset valuations averaged 1580 pesos including

houses and half the households were in debt with loans averaging 430 pesos in the wet season and 230 pesos in the dry season. Most loans were for consumption rather than production purposes. Almost all the landless households derived their income solely from agriculture, working on average 243 mandays per year split equally between seasons with an average household income of 2400 p. Females contributed little directly to family income, of necessity allocating most of their time to house-keeping and child rearing.

Harvesting and threshing arrangements are crucial to the earnings of the landless - half their income comes from crop shares of the rice harvest; harvesting, threshing and transplanting are traditionally carried out by hired labor. Opinions surveys of the landless revealed that they thought introduction of small mobile mechanical threshers had improved their situation due to reduced hauling and faster threshing which enabled them to harvest additional fields and receive their crop share earlier. A decline in sharing rates from $1/6^{th}$ to $1/8^{th}$ for both manual harvesting and threshing down to $1/10^{th}$ using mechanical threshers was outweighed by these advantages. In addition under the new threshing technology more women and children had access to an income source in less physically demanding tasks. Workers were however aware that machines had led to an excess supply of harvesting labor in the villages and feared further declines in sharing rates in the future particularly if mechanical reapers were introduced into labor-surplus areas.

Conclusions

Evidence presented shows that, in a comparison of machinery users with non-users, holding all other factors constant, no significant output gains could be attributed to the use of tractors in this region of the Philippines. Substitution of machinery for labor in land-preparation operations has taken place with family labor being mainly displaced. Changes in harvesting technology are resulting in declining crop shares going to manual harvester laborers but their incomes may be maintained when it is possible to harvest greater areas. In labor-surplus villages this will not be possible in the long run and competitive forces may lower the harvesters' crop share even further.

However the total effect of the tractor-carabao (buffalo) choice is not fully captured by localized, partial-equilibrum analyses. Indirect, non-local effects of mechanization are important in assessing overall efficiency and equity changes. Such effects caused by production and consumption interactions between the agricultural and non-agricultural sectors must also be modelled. Mechanization generates demand for agricultural machinery with associated backward linkages which in turn generates income and employment. Consumption linkages alter the final demand pattern across the economy and at each

stage the changed gross output will be distributed between wages and profit. The magnitude of import leakages associated with mechanization is a crucial component in the overall impact on employment and income distribution as are labor market conditions. The first round displacement of family labor by machines is only part of the story; what are the indirect effects as former family labor moves into the hired labor market causing involuntary labor displacement? General equilibrium studies are being carried out to investigate such linkages (see for example Ahammed and Herdt (1983)) and preliminary results suggest that rice production-employment and equity goals would be better promoted by encouraging intensified irrigation rather than distorting market forces to facilitate further mechanization of rice production.

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Table 1. Sales of agricultural machinery in the Philippines.

	Type of machine				
	Four-wheel tractor	Power tiller	Engine	Irrigation pump	Farm processing machine
1960	583				
1961	813				
1962	994				
1963	863				
1964	950				
1965	607	1505[a]			
1966	664	1932			
1967	1531	3058			
1968	1630	1873			
1969	1358	910			
1970	974	475			
1971	1083	680			
1972	1120	1408			
1973	1517	3120			
1974	1655	6720			
1975	2143	11077			
1976	1074	8937			
1977	1318	9209	10107		
1978	1266	7803	40526	4331	3169
1979	1224	5379	65115	4106	3914
1980[b]	433	2298	15159	1488	2181

[a]Cumulative total of power tillers sold from 1960 to 1965.

[b]Includes sales from January to August only.

Table 2. Distribution of sample households among irrigation/mechanization classes for wet season 1979.

Irrigation	Mechanization			
	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 3. Regression coefficients for linear cropping intensity function 312 households, Philippines, 1979/80

Explanatory variables	Estimated coefficient	
Intercept	1.20	(32.3)
Area managed	-0.02	(-1.92)
Dummy (fully mechanized)	0.09	(1.41)
Dummy (partial mechanized)	0.06	(1.30)
Dummy (gravity irrigated)	0.72	(14.71)
Dummy (pump irrigated)	0.39	(7.5)
R^2	0.62	

Figures in parentheses are t-statistics.

Table 4. Coefficients of a Cobb-Douglas Production Function, 312 households, the Philippines, wet season, 1979.

(Per ha specification; dependent variable-yield in kg/ha)

Explanatory variables	Estimated coefficient	
Intercept	5.81	(23.52)
Area cultivated (ha)	-0.02	(0.43)
Nitrogen (kg/ha)	0.19	(5.1)
Pesticides (pesos/ha)	0.14	(4.6)
Preharvest labor (mds/ha)	0.16	(2.6)
Dummy (fully mechanized)	0.01	(0.15)
Dummy (partial mechanized)	0.02	(0.28)
Dummy (gravity irrigated)	0.43	(5.88)
Dummy (pump irrigated)	0.13	(1.98)
R^2	0.56	

Figures in parentheses are t-statistics.

Table 5. Average labor use (hours per ha) by crop activity, Nueva Ecija, Philippines, wet season, 1979.

	Rainfed		Irrigated	
	Non mech.	Partial mech.	Partial mech.	Fully mech.
Land preparation	146	98	66	47
Seedbed preparation & planting	176	154	191	214
Fertilizing	6	6	9	9
Spraying	9	6	13	15
Weeding	15	18	5	2
Harvesting/threshing & post-harvest	261	243	247	225
Total:	631	525	531	510
% hired labor	56	48	74	84
Yield (kgs)	1902	1826	3860	3803
% using threshers	40	48	42	56
% transplanting	95	93	94	98
Sample size	77	46	79	54

Table 6. Regression results for land preparation mandays per hectare, Nueva Ecija, Philippines, wet season, 1979.

Explanatory variables	Coefficient			
	Rainfed		Irrigated	
Intercept	21.1	(16.8)	19.4	(11.2)
Area planted (ha)	-2.7	(-5.5)	-0.6	(-2.1)
Dummy (fully mechanized)			-11.6	(-6.3)
Dummy (partial mechanized)	-2.6	(-2.0)	- 9.3	(-5.1)
R^2	0.23		0.30	
n	124		139	

Figures in parentheses are t-statistics.

Table 7. Average rice production costs and returns per hectare, wet season, 1979-80, Philippines (pesos/hectare).

	Gravity irrigated			Pump irrigated		Rainfed	
	Mech.	Part. mech.	Non-mech.	Part. mech.	Non-mech.	Part. mech.	Non-mech.
A. Production costs:							
1. Cash inputs	978	976	834	490	676	407	387
2. Total labor costs	971	997	1241	660	699	612	623
a) Family	137	131	680	159	232	189	251
b) Hired	833	865	561	501	467	422	371
3. Total land rent	630	586	470	565	541	424	443
a) Owned land	231	223	232	339	340	357	303
b) Rented land	399	363	237	226	200	66	140
4. Capital	1241	916	807	839	1172	540	378
a) Owned	956	665	763	617	1063	356	306
b) Hired	285	251	43	222	109	184	71
5. Total cost	3823	3477	3468	2582	3083	987	1983
6. Total paid-out	2498	2456	1780	1470	1448	1091	971
B. Total output	4437	4510	3785	2881	2839	2075	2147
C. Gross value added	3458	3533	2951	2390	2162	1667	1759
D. Gross Family Factor Income	1939	2053	2005	1411	1390	980	1176
E. Residual	614	1033	317	298	-244	83	312

Table 8. Percentage earner shares, wet season, 1979-80, Nueva Ecija, Philippines.

	Gravity irrigated			Pump irrigated		Rainfed	
	Mech.	Part mech.	Non-mech.	Part. mech.	Non-mech.	Part. mech.	Non-mech.
1. Cash inputs	25	24	23	18	26	22	21
2. Hired labor	21	19	17	18	17	22	19
3. Landlord	13	8	7	9	9	3	8
4. Hired capital	7	5	1	8	3	11	3
5. Operator	31	41	50	45	42	39	47
TOTAL	100	100	100	100	100	100	100