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THE CONSEQUENCES OF SMALL RICE FARM MECHANIZATION PROJECT

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FARM LABOR UTILIZATION AND EMPLOYMENT IN TWO SELECTED MUNICIPALITIES IN NUEVA ECIJA - - A PRELIMINARY ANALYSIS

By

J. F. Sison and P. B. Moran
The International Rice Research Institute
Los Baños, Laguna

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ABSTRACT

Mechanization of small rice farms may be assessed in terms of its impact on land preparation labor requirements. Although it is difficult to solely attribute the findirgs to mechanization, the study shows that farms using two-wheel tractors exhibited significant reductions in labor use for land preparation as well as for all other farm operations. This decline implies that no offsetting effects in labor utilization in other operations, such as post-production were evident inspite of higher yields produced by mechanized farms. However, it is inappropriate to ascribe this yield-difference to mechanized land preparation since a variety of factors, including higher levels of chemical and fertilizer application by mechanized farms, may account for this difference. Inspite of its analytical weaknesses, the study provides important information regarding differences in labor utilization and employment between mechanized and non-mechanized farms.

INTRODUCTION

The issue of farm mechanization in small rice farms in the Philippines has been the center of controversy since the 1960's. Aside from whether farm mechanization has increased farm output significantly, and subsequently farm incomes, questions have to be answered with regard to its effects on farm labor utilization and employment. These issues are critical to many developing countries if the problems associated with large increases in unemployment are to be avoided.

The effects of farm mechanization are illustrated graphically in Figure 1. Mechanization, like biological and chemical technologies, may result in three possible effects. They are: (1) output effect, which results from the upward movement of the total product curve from $TP^1{}_L$ to $TP^2{}_L$ -- implying that for all levels of input, larger amounts of output are obtained, (2) cost effect, which arises from the downward shift of the average and marginal cost curves, i.e., $AC^1{}_L$ to $AC^2{}_L$ and $MC^1{}_L$ to $MC^2{}_L$, respectively -- implying that at a given output price, farmers realize higher farm incomes and (3) labor effect, which results from the substitution of farm mechanical power for manual and/or animal power.

Although government policies may directly affect the direction and rate of farm machinery adoption, the use of farm mechanical power as a substitute for manual and/or animal power has resulted in the development of two schools of thought regarding labor effects of mechanization (Binswanger, 1978). Some studies have shown that farm mechanization allows for more efficient farm operations which, in turn, positively affect yields as well as allows for greater intensity of land use. As a result of higher production and greater intensity of land cultivation, proponents of farm mechanization showed that the increase in the labor requirements of certain farming activities, i.e., harvesting, had an offsetting effect on the amount of labor displaced from other farm operations, such as land preparation. Studies by Barker, Meyers, Crisostomo and Duff (1972) for the Philippines, Inukai (1970) for Thailand, and Thapa (1979) for Nepal follow this line of argument. Such argument is illustrated in Figure 1.

Assume that at zero mechanization hours, as indicated by m_o in the labor effect quadrant, the amount of farm output produced by L_o labor is q_o. This input-output relationship is indicated by point b on $TP^1{}_L$ as well as by point r on isoquant q_o in the lower quadrant. The cost per unit of output is AC_o. On the other hand, the employment of m hours of mechanical power in combination with L_o labor hours may result in a higher level of output produced, as indicated by point s on isoquant $q^*{}_o$ in the labor effect quadrant. This input-output relationship is also observed in the output effect quadrant, at point c on the total product curve, $TP^2{}_L$. The total output effect of mechanization is $q_o q^*{}_o$ while the cost effect is $AC^{**}{}_o AC^*{}_o$. If the argument of the mechanization proponents is adhered to no change in the total labor utilization may be observed. Therefore, total farm labor employment may remain at the same level, that is, at L_o labor hours.

However, other researchers have indicated that mechanization of certain farm operations has resulted in the replacement and displacement of labor which is undesirable in countries where manual power is abundant and farm operations are labor intensive. This may be exemplified by the study conducted by Bose and Clark (1969) in Pakistan, as well as those by Raj Krishna (1974) and Shah and Singh (1970) in India.

Again this may be illustrated graphically in Figure 1. It was previously stated that mechanization, as a form of technological change, may result in greater output for all levels of input. This is indicated by the upward shift of the total product curve from $TP^1{}_L$ to $TP^2{}_L$. Recall that prior to mechanical power adoption, L_o labor hours produces q_o output. However, under a farm mechanization scheme, the same amount of output may be produced by a combination of m'_o mechanization hours and L'_o labor hours. Since L'_o is less than L_o, the total labor displaced by mechanical power adoption is $L'_o L_o$.

From the two different views on the labor impact of farm mechanization, it becomes apparent that there is a need to investigate how the adoption of farm machinery by small rice farms in the Philippines has affected labor utilization. In this connection, a preliminary analysis of the effects of mechanization will be attempted in order to answer the following questions:

(1) Do mechanized and non-mechanized farms differ significantly in labor utilization? In relation to this, it may be interesting to find out whether farms using different modes of mechanization differ in labor usage.

(2) Do mechanized rice farms produce significantly higher levels of output per hectare than non-mechanized? If so, has this resulted in more post-production labor requirements for mechanized farms? Furthermore, is this increase in post-production labor requirements significant enough to offset the labor displaced from land preparation operations?

(3) What other factors aside from mechanization affect labor utilization on small rice farms?

Before undertaking these tasks, a definition of a mechanized farm is presented. For the purpose of this study, the utilization of mechanical power in land preparation, i.e., seedbed preparation, plowing, harrowing and levelling, as well as in post-production activities, i.e., threshing, defines a mechanized rice farm. In this respect, farms using carabao power for land tillage and manual labor for threshing are classified as non-mechanized farms (or C). On the other hand, farms which have availed of the services of two-wheel tractors (or a combination of two-wheel tractor and carabao power) as well as the services of mechanical threshers are defined as mechanized farms. Within the classification of mechanized farms, five types are defined. They are:

(a) Carabao/thresher farms (CT) - those that utilize carabao power for land preparation and mechanical thresher for post-production operations,

(b) Two-wheel tractor farms (TW) - those that utilize two-wheel tractors for land preparation and manual labor for post-production operations,

(c) Two-wheel tractor/thresher farms (TWT) - these are rice farms which use two-wheel tractor for land preparation and mechanical threshers for post-production operations,

(d) Two-wheel tractor/carabao farms (TWC) - these are rice farms which use a combination of two-wheel tractor and carabao power for land preparation and manual labor for post-production operations, and

(e) Two-wheel tractor/carabao/thresher farms (TWCT) - these are farms which use two-wheel tractor and carabao power for land preparation and mechanical thresher for post-production operations.

DATA SOURCE

The data for this study was obtained from the farm survey conducted by IRRI in Nueva Ecija for the "Consequences of Small Rice Farm Mechanization Project". The project site consists of two municipalities, Cabanatuan City and Guimba, from which sample villages were selected for farmer interviews. Referring to Table 1, it may be said that all the surveyed villages are homogeneous in terms of average number of household members, average years of education and experience of farmer, average farm area and per cent area planted to new rice varieties.

Based on this population, farm households with different modes of mechanization were selected and classified into the different farm classifications mentioned previously. Except for the average area per farm and the average yield per hectare, the sample farms in all classifications may be considered to be homogeneous (Table 2). Farms which utilized carabao power exhibited the smallest area as indicated by carabao and carabao/thresher farms with 1.3 hectares and 1.5 hectares, respectively. It is interesting to note that the same farms, with the exception of two-wheel tractor/carabao farms, obtained the lowest yield per hectare among the different farm-types. On the other hand, farms which mainly depended on two-wheel tractors for land preparation possessed the largest farm area. Two-wheel tractor farms averaged 2.1 hectares while two-wheel tractor/thresher farms averaged 2.4 hectares. These same farms exhibited the highest yield per hectare. The average yield of two-wheel tractor farms amounted to 4,181 kilograms per hectare while two-wheel tractor/thresher farms produced an average of 4,035 kilograms.

In terms of the distribution of farms using mechanical power, Table 3 shows that most of the mechanized farms are located within the municipality of Cabanatuan City. Furthermore, the majority of the mechanized farms are found in the villages of San Isidro and Lagare. On the other hand, most of the farms with non-mechanized land preparation operations are located in Guimba.

COMPARATIVE ANALYSIS OF NON-MECHANIZED AND MECHANIZED FARMS

Comparison of yield

Before attempting to investigate the labor impact of farm machinery adoption in certain farm operations, it is necessary to assess whether mechanization has a significant effect on farm output. A very simple method of accomplishing this task, although with many limitations, is to compare the average yield per hectare of both non-mechanized and mechanized farms. First, it is assumed that mechanized farms realize higher yields than non-mechanized farms due to improved efficiency of land tillage as well as timeliness of farm operations. Under the null hypothesis that no yield-difference exists between these two farm-types, a t-test was conducted. The mechanized farms considered for this test were those that used mechanical power for land preparation, i.e., TW, TWT, TWC, TWCT while farms which used carabao power for land preparation, such as C and CT, were classified as non-mechanized farms.

Table 4 presents the yields of these two types of farms. It may be observed that farms with mechanized land preparation operations have a significantly higher yield per hectare than those which did not mechanize such operations. It is important to note that it is impossible to attribute this yield-difference solely to mechanization since the differences in realized yield between farms may be the result of other factors, such as high levels of fertilizer and chemical application. Table 5

reports that mechanized farms use more chemicals and fertilizer, as reflected by the amount of expenditure incurred for these items. However, it is necessary to maintain the assumption that mechanization increases yield as a basis for later discussion on the labor impact of mechanization.

Comparison of labor utilization

The total labor hours per hectare utilized by each farm-type is presented in Table 6 for both wet and dry seasons of crop year 1979-1980. In terms of the total labor hours devoted per operation among the different farm-types, obvious differences are observed in those farm operations in which mechanical power was used in combination with carabao and/or manual power. For example, for land preparation, farms such as TW, TWT, TWC and TWCT utilized considerably lower levels of manual labor than farms with non-mechanized land preparation operations, i.e., C and CT. With regard to post-production, in general, farms which availed of the services of mechanical threshers required less amount of labor hours to complete such operation compared to farms which relied mainly on manual labor. These observations are true for both seasons.

Furthermore, it may be observed that mechanized land preparation resulted in a decrease in the proportion of the total hours required to accomplish this operation to the total labor hours required to complete all the farm operations. Specifically, note that during the wet season, to accomplish land preparation operations, carabao farms required 18% of the total labor hours while carabao/thresher farms needed 19%. However, for mechanized farms, i.e., TW, TWT, TWC and TWCT, the proportion spent for these operations was much lower. During the dry season, these same farm-types exhibited similar labor utilization patterns. With regard to post-production, it may be generalized that those farms which utilized mechanical threshers exhibited less labor requirements for this farm operation in both seasons. This also resulted in the decrease in the proportion of total labor hours devoted to this particular operation in relation to total labor hour requirements for all operations especially during the wet season.

Table 7 gives an idea of how the total labor hours for each season are distributed among its components of hired and family labor. From this table, it may be observed that for land preparation, total hired and family labor hour requirements of carabao and carabao/thresher farms were higher than those farms with mechanized land preparation. Furthermore, thresher-using farms employed less hired labor, as well as requiring less family labor hours, for post-production compared to non-thresher users. An exception to this is the dry season carabao/thresher farm classification which presented higher post-production labor usage than carabao farms of the same season.

Of the four major farm operations, land preparation and care/cultivation largely depended on family labor, as indicated by Table 7.

This may also be observed in Table 8 which presents the per cent hired and per cent family labor per farm operation, for wet and dry seasons.

For example, for wet season carabao farms, 77% of the total land preparation labor was accomplished by family labor while 23% was done by hired labor. For the same farm classification, care/cultivation was completed by 87% family labor and 13% hire labor. It should be noted that due to the prevalent use of chemicals, care/cultivation operations have become less labor intensive. Weeding work, which used to be accomplishe mainly by hired labor, has been considerably reduced through the proper application of herbicides/weedicides. Furthermore, it should be mentioned that the cultivation of early-maturing rice varieties has shortened the period within which all weeding activities must be accomplished.[1] In order to adjust to this situation, farmers in the study area have supplemented weeding labor with more intensive use of herbicides/weedicides. As a consequence, hired and family labor input requirements of care/cultivation operations decreased.

On the other hand, planting and post-production operations required more hired labor than family labor since these operations are labor intensive in nature.

It should be noted that significant differences in the labor hour utilization of the six different farm-types are not observable for those farm operations which were not mechanized at all, such as planting and care/cultivation. Furthermore, no distinct pattern of hired labor employment and family labor use may be noticed for these same operations in all farm classifications.

However, it may be concluded that mechanized farms, specifically those with mechanized land preparation operations, used less labor (Table 9). This is reflected by the fact that these farms utilized less family labor hours, as well as employed less hired labor, to accomplish all farm operations. Based on these observations, it may be said that although the yield per hectare of mechanized farms was found to be significantly higher than non-mechanized farms, the yield difference was not increased post-production labor utilization.

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[1]It should be noted that most of the weeding activities are done during the vegetative stage, that is, the period from transplanting to panicle initiation. This is approximately 35 days for IR50 to 65 days for IR8 varieties. In this conncection, at least 280-520 man-hours are required to complete the magnitude of weeding work in such a short time so that proper timing of fertilizer application may be accomplished. This is, specifically, at panicle initiation. The importance of such scheduling prevents the weeds from competing with the rice plants for the fertilizer nutrients necessary for the rice reproductive stage. In order to accomplish these tasks at the proper time, family labor must be supplemented with large amount of hired labor.

Furthermore, farms in the thresher-user category required less hired labor for post-production operations than non-thresher users. This resulted in the reduction of total labor hours utilized by thresher-using farms.

STATISTICAL ANALYSIS

t-test

The tables presented above provide weak evidence regarding differences in labor utili-ation and employment between non-mechanized and mechanized farms, especially in relation to land preparation. However, there is a need to test these differences in order to assess whether or not labor utilization and employment between these two farm-types are statistically significant.

To facilitate statistical analysis, it was assumed that the small rice farms considered in the study do not differ in the amount of labor utilized during the wet and dry seasons. This is supported by Table 10 which presents the results of the t-tests, verifying whether the mean labor utilized and the mean labor employed for both seasons, for all farm classifications, were statistically different. It may be observed that, in general, the t-values were not significant with the exception of the hired labor and total labor means for the carabao/thresher farms. Based on these findings, subsequent comparative analyses of the different farm classifications will pertain to crop year 1979-1980.

An initial test was conducted to statistically verify the findings presented in Table 6, i.e., mechanized farms utilize less labor than mechanized farms, particularly in those operations which are mechanized. Table 11 reports the results of the test. The non-mechanized farms considered for this test only consisted of carabao farms while the rest of the classifications were combined under the mechanized farm group.

The results show that, although the mechanized farm-group required less total labor hours compared to those farms which relied completely on manual and animal power, the difference in total labor hour utilization between these two groups was not statistically significant. In terms of the labor hours utilized for each farm operation, only land preparation labor exhibited a significant difference between non-mechanized and mechanized farms.

At this point, it should be mentioned that the inclusion of carabao/thresher farms in the classification of mechanized farms may have affected the t-tests results in Table 11. This is due to the fact that these farms utilized more labor hours than any of the mechanized farm-types, as seen in Table 6. As a result, the mean total labor hours of non-mechanized farms may have been biased downward, while the mean total labor hours of mechanized farms may have been biased upward, by this

inclusion. Thus, resulting in insignificant t-values of the mean labor hour differences for most of the farm operations.

To investigate this possibility, the carabao/thresher farms were transferred from the mechanized to the non-mechanized classification and a similar test was conducted.[2] The findings are presented in Table 12. The labor hour values in this table confirmed the bias mentioned above which was caused by the inclusion of the carabao/thresher farms under the mechanized farm classification. It may be noticed that, except for care/cultivation, the differences in the mean labor utilization in all operations were highly significant. Thus, implying that those farms with mechanized land preparation activities required less labor to accomplish farm operations.[3]

In terms of differences in family labor hour requirements between non-mechanized and mechanized farms, the t-values in Table 13 indicate that the latter farm-group significantly required less family labor, for all operations, than non-mechanized farms.[4]

Differences in hired labor employment are presented in Table 14. It may be observed that only land preparation exhibited a significant difference in the mean hired labor hours between the two farm classifications. This implies that those farms using two-wheel tractors, solely or in combination with a carabao, significantly employed less hired labor for land preparation.[5]

A test for labor differences between thresher and non-thresher users was also conducted to investigate the impact of threshing machines on labor utilization for these two farm classifications. The results in Table 15 show that thresher-using farms utilized lower levels of post-production labor, compared to non-thresher using farms, and that the labor difference is statistically significant.

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[2]This classification is thus maintained for the succeeding analyses. Furthermore, since it is more appropriate to attribute increases in yield to timeliness and increased efficiency in land tillage afforded by mechanized land preparation, this new classification is more realistic.

[3]A similar test was conducted to find out how the mean labor hour utilization differs among the mechanized farms, i.e., mechanized land preparation, with different modes of mechanization. The results are presented in Appendix Table 3.

[4]Test for mean differences in family labor utilization among mechanized farms are presented in Appendix Table 4.

[5]Test for mean differences in hired labor utilization among mechanized farms are presented in Appendix Table 5.

The basic conclusions are:

(1) Mechanized farms required less total labor hours to accomplish all farm operations than non-mechanized farms.

(2) Family labor hour requirements of mechanized rice farms are significantly lower than those farms which are non-mechanized.

(3) Farms which utilized two-wheel tractors for land preparation significantly reduced their employment of hired labor.

(4) The major effect of mechanical power adoption is the significant reduction in the labor input requirements of farms using two-wheel tractors for land preparation. There is no doubt that in this operation, these machines directly affect labor utilization and employment.

(5) Based on the observations presented in (1), (2) and (3), it may also be concluded that the significantly higher yields of mechanized farms have not increased post-production labor utilization in these farms.

(6) Mechanical threshers have the potential of replacing and displacing post-production labor.

The basic weakness of the above method of analysis is that it mainly attributes the difference in labor utilization and employment between non-mechanized and mechanized farms to mechanical power adoption. However, this may not necessarily be the case. It is known that other factors, aside from mechanization, affect the degree of labor utilization and employment among farm groups. In order to investigate which of these factors had a significant impact on labor input requirements, a covariance analysis was conducted. The models used for this analytical method are discussed below.

Covariance analysis

The covariance analytical approach is mainly based on the following relations:

$$(1)\quad L_i = \alpha_0 + \alpha_1 M_1 + \alpha_2 M_2 + \alpha_3 M_4 + \alpha_4 M_5 + \alpha_5 S + \alpha_6 I + \alpha_7 T + \alpha_8 A + \alpha_9 IM_1 + \alpha_{10} IM_2 + \alpha_{11} IM_4 + \alpha_{12} IM_5 + \alpha_{13} SA + e$$

where: L_i refers to the total man-hours in terms of (1) total labor, (b) total hired labor and (c) total family labor.

M_i refers to a mechanization dummy which takes a value of unity if the farm belongs to mechanization group i, such as: $M_1 = TW$, $M_2 = TWC$, $M_4 = TWT$ and $M_5 = TWCT$. Carabao farms (C) and carabao/thresher farms (CT) are the reference groups. Note that these are farms with non-mechanized land preparation operations.

S is a season dummy which takes a value of unity for dry season and zero for wet season.

I is an irrigation dummy which takes the value of unity for irrigated farms and zero for non-irrigated farms.

T is a tenure status dummy which takes the value of unity for farmer-owned farms and zero, otherwise.

A is the total land area in hectares, devoted to rice production.

e is the residual term.

It should be noted that the coefficients of the mechanization dummies measure group differences between mechanized and non-mechanized farms. For example, α_1, reflects how much more (if $\alpha_1>0$) or less (if $\alpha_1<0$) labor hours were utilized by M_1 farm group (or TW farms) relative to farms with non-mechanized land preparation operations. If L refers to total labor input, then α_1 measures the difference in the total labor use between C/CT farms and TW farms.

It may be observed that equation (1) allows for non-additive effects which measure the interactive influence of type of irrigation and type of mechanization made adopted by each farm household as well as the interaction of season and area. The significance of the interaction effects was tested by fitting a constrained version of equation (1) as follows:

$$(2)\quad L_i = \alpha_0 + \alpha_1 M_1 + \alpha_2 M_2 + \alpha_3 M_4 + \alpha_4 M_5 + \alpha_5 S + \alpha_6 I + \alpha_7 T + \alpha_8 A + e^*$$

A test was conducted in order to find out whether the regression coefficients of the interaction terms are equal to zero, with the use of an F-statistic based on the residuals of the estimating equations for (1) and (2). Table 16 presents the results of the covariance regressions. Since the coefficients of the interaction terms were found to be statistically insignificant, the additive model (Model 1) is as good a specification as the non-additive model (Model 2). Thus, the former will be the basis of subsequent discussion.

Reductions in family and total labor utilization were observed to occur in all farms with mechanized land preparation operations. This is implied by the negative regression coefficient of all mechanization dummies of these two labor covariance models. On the other hand, due to the statistically insignificant mechanization dummy coefficients of the hired labor model, it is difficult to conclude that reductions in hired labor employment occurred. However, it may be generalized that the results provide information with regard to the direction of labor change due to mechanization.

The seasonal effect on labor utilization was found to be significant only for total family labor. The sign of the coefficient of this explanatory variable implies that the total family labor hour requirements during the dry season is lower by 48 hours as compared to the wet season.

However, for both hired and total labor utilization no significant change was observed between seasons.

Another observation is that, regardless of the tenure status, labor utilization and employment remained the same for farm owners and non-farm owners. Irrigation labor effects were, likewise, found to be significant except for the family labor model.

A highly significant variable which positively influenced labor utilization and employment is farm size (A). For all regressions, this variable was found to be significant up to 1%.

It should be mentioned that it would be appropriate to estimate a labor covariance model pertaining to land preparation operations which could serve as a basis for analyzing labor differences in land preparation between mechanized and non-mechanized rice farms. A model for post-production operations could also serve the purpose.

CONCLUSION

The adoption of farm machinery by small rice farms has been observed to affect labor utilization mainly in those operations in which mechanical power can be substituted for manual and/or animal power. This supports the substitution view as cited by Binswanger (1978). Of the major operations of rice production, mechanization significantly reduced labor utilization and employment in land preparation and post-production, as verified by the statistical tests. Although mechanized farms were found to produce higher levels of output per hectare, the reduction in the overall labor utilization of mechanized farms implies the non-existence of offsetting effects of output benefits as mentioned by the mechanization proponents. The evidence shows that the use of two-wheel tractors, solely or in combination with carabao power, in land preparation has reduced family labor requirements as well as hired labor employment. In the case of farms using mechanical threshers, it may be concluded that these farms utilized less family and hired labor in post-production operations compared to those farms which did not use such machinery. Furthermore, labor utilization and employment effects differed among farms with different modes of mechanization. Aside from two-wheel tractor usage, another factor that was observed to affect labor utilization is farm size. This factor exhibited a positive effect on labor utilization.

It should be mentioned that the conclusions obtained from the statistical analyses are consistent with those obtained from the tabular analysis. However, both methods of analyses are not sufficient to arrive at definite conclusions regarding the impact of mechanization on labor input utilization in small rice farms. In the first place, the basic weakness of the t-test is that this method of analysis does not provide information regarding the causal relationship between mechanization and labor utilization.

Although mechanized farms were observed to produce higher yields than non-mechanized farms, farm output may be more directly related to land quality and climatic factors. Farm output may at best be ascribable to mechanization only indirectly. Therefore, the results of the t-test for yield-difference, likewise, cannot be considered conclusive as far as attributing this difference solely to mechanization. It should be noted that the decision to adopt two-wheel tractors may be partly influenced by a whole package of modern rice technology which includes higher fertilizer application, more intensive use of herbicides/ weedicides and more intensive cultural management. Since it was observed that mechanized farms have higher expenditures on chemicals and fertilizer, higher yields of these farms may have resulted from the interaction of any of these factors and not from mechanization alone.

Furthermore, covariance analysis is not sufficient to arrive at firm conclusions regarding the impact of two-wheel tractor on labor input utilization. It may be that land quality may affect the decision to mechanize -- a decision which would affect labor utilization directly. If this is the case, land quality would have an indirect effect on labor use.

Due to the difficulty in specifying this variable, it was not included in the regressions. However, if land quality and tractor ownership are positively correlated, then the coefficient of the mechanization variables would have captured some of the effects of this excluded variable.

It should also be noted that the method of covariance analysis fails to separate mechanization effects on post production labor which arise indpendently of the level of inputs utilized in rice production. Such a task requires the estimation of net output effects attributable to two-wheel tractors and then the application of an established parameter to incremental output to calculate post-production employment effects.

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Table 1. Selected average characteristics of surveyed villages.[a]

Village	Number of Households	Household members	Years experience	Years education	Farmer's age	Years mech-anized	Rice area per farm (ha)	% area planted to new rice varieties	Yield/ha (kg)
Cabanatuan City									
San Isidro	49	5.9	22.4	4.9	47.6	8.3	2.6	100	3211
Lagare	47	5.4	17.5	3.7	46.3	7.7	2.2	100	4536
Kalikid Sur	24	5.9	18.9	3.9	45.1	5.2	2.1	97	1509
Caalibangbangan	76	5.9	21.2	4.5	44.7	6.6	1.8	100	3853
Guimba									
Galvan	35	5.5	21.5	3.9	46.3	8.9	1.7	99	1943
Narcavan I	39	5.6	14.2	4.8	39.7	5.6	1.9	100	2264
San Andres	45	5.6	17.1	5.4	41.6	7.8	2.0	100	1945
Bunol	53	5.5	19.3	5.1	45.1	4.6	1.8	97	2292

[a]Based on 1979 wet season data.

Table 2. Selected average characteristics of sample farms, 1979-1980.[a]

Farm Type	Number of Households	Household members	Years experience	Years education	Farmer's age	Years mech-anized	Rice area per farm (ha)	% area planted to new rice varieties	Yield/ha (kg)
Carabao	98	5.6	18.4	4.3	41.8	-	1.3	98	2270
Carabao/ thresher	105	5.6	17.8	4.6	42.6	-	1.5	98	3008
Two-wheel	32	5.4	20.7	4.0	44.4	7.8	2.1	100	4181
Two-wheel/ thresher	95	5.8	21.4	4.1	47.6	7.5	2.4	100	4035
Two-wheel/ carabao	37	5.9	19.2	5.1	43.1	7.5	1.9	100	2854
Two-wheel/ carabao/ thresher	52	5.2	17.6	4.8	43.7	6.1	2.0	100	3664

Information is based on the number of years mechanical power has been used for land preparation only.

Table 3. Distribution of the different farm-types among the eight surveyed villages, crop year 1979-1980.

Farm Type	Cabanatuan City				Guimba				Total
	San Isidro	Lagare	Kalikid Sur	Caalibang-bangan	Galvan	Narvacan I	San Andres	Bunol	
				Wet Season					
Carabao	2	-	16	7	5	19	7	16	72
Carabao/ thresher	-	1	2	-	19	14	10	12	58
Two-wheel	10	6	-	5	-	-	-	-	21
Two-wheel/ thresher	18	21	-	1	-	-	-	-	41
Two-wheel/ carabao	5	2	2	10	4	1	7	-	31
Two-wheel/ carabao/ thresher	2	3	-	6	3	-	11	2	27
				Dry Season					
Carabao	2	1	-	2	5	5	10	1	26
Carabao/ thresher	1	3	-	6	2	9	-	26	47
Two-wheel	5	2	-	3	-	-	1	-	11
Two-wheel/ thresher	21	22	-	11	-	-	-	-	54
Two-wheel/ carabao	-	1	-	2	-	1	2	-	6
Two-wheel/ carabao/ thresher	8	5	-	12	-	-	-	-	25

Table 4. Comparison of yield per hectare (kg) -- Non-mechanized land preparation versus mechanized land preparation.

Farm classification	Average yield per hectare[a] (kg)
Non-mechanized land preparation	2651.82
Mechanized land preparation	3764.90
t-value	-7.1655*

*Significant at P = 1%

[a]Average yield per hectare for crop year 1979-1980

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Table 5. Comparison of chemical and fertilizer expenditures between non-mechanized and mechanized farms, crop year 1979-1980.

Farm Classification	Chemical expenditure/ hectare	Fertilizer expenditure/ hectare	Amount of fertilizer applied/hectare (kg)	Number of Observations
non-mechanized	₱ 101	₱ 347	203	203
mechanized	₱ 168	₱ 400	239	216
t-value	-6.9962**	-2.0916*	-2.4505**	

**Significant at P = 1%

*Significant at P = 5%

Table 6. Average labor hours used per hectare for various farm operations, crop year 1979-1980.

Farm Classification	Average Labor Hours Used For Various Farm Operations									
	Land Preparation		Planting		Care/ Cultivation		Post-production		Total Hours	
	Hours	%	Hours	%	Hours	%	Hours	%	Hours	%
					Wet Season					
Carabao	105	18	198	33	34	6	251	43	588	100
Carabao/thresher	112	19	211	35	32	5	242	41	597	100
Two-wheel	30	6	211	43	22	4	233	47	496	100
Two-wheel/thresher	37	8	199	45	26	6	182	41	444	100
Two-wheel/carabao	61	12	178	36	32	6	224	46	495	100
Two-wheel/carabao/ thresher	54	11	208	42	24	5	206	42	492	100
					Dry Season					
Carabao	143	23	222	35	26	4	235	38	626	100
Carabao/thresher	158	20	291	37	32	4	314	39	795	100
Two-wheel	59	9	217	33	36	6	340	52	652	100
Two-wheel/thresher	33	8	190	44	29	6	182	42	434	100
Two-wheel/carabao	58	11	228	43	29	5	216	41	531	100
Two-wheel/carabao/ thresher	55	13	166	38	32	7	181	42	434	100

Table 7. Distribution of labor hours per hectare, hired and family, for various farm operations -- crop year 1979-1980.

Farm Classification	Land Preparation		Planting		Care/ Cultivation		Post-production		Total labor hours	
	H[a]	F[b]	H	F	H	F	H	F	H	F
					Wet Season					
Carabao	24	81	152	45	4	30	174	77	354	233
Carabao/thresher	30	82	176	35	-	32	160	82	366	231
Two-wheel	4	26	207	4	3	18	232	2	446	50
Two-wheel/thresher	6	31	180	18	2	23	167	16	355	88
Two-wheel/carabao	19	42	154	24	1	30	193	31	367	127
Two-wheel/carabao/ thresher	19	35	195	13	1	22	160	47	375	117
					Dry Season					
Carabao	18	125	183	39	1	25	130	105	332	294
Carabao/thresher	21	137	253	39	-[c]	32	270	43	544	251
Two-wheel	6	54	161	56	2	33	239	101	408	244
Two-wheel/thresher	7	27	177	13	5	24	179	3	368	67
Two-wheel/carabao	11	47	209	20	-	29	216	-	436	96
Two-wheel/carabao/ thresher	13	42	153	12	5	27	180	1	351	82

[a]Hired labor

[b]Family labor

[c]Considerably less than one hour

Table 8. Per cent labor hours utilized per hectare, hired and family labor, for various farm operations.

Farm Classification	Land Preparation		Planting		Care/ Cultivation		Post-production		Total Labor Hours	
	H[a]	F[b]	H	F	H	F	H	F	H	F
					(Percent)					
					Wet Season					
Carabao	23	77	77	23	13	87	69	31	60	40
Carabao/thresher	27	73	83	17	-	100	66	34	61	39
Two-wheel	13	87	98	2	15	85	99	1	90	10
Two-wheel/thresher	15	85	91	9	9	91	92	8	80	20
Two-wheel/carabao	32	68	86	14	5	95	86	14	74	26
Two-wheel/carabao/ thresher	35	65	94	6	6	94	77	23	76	24
					Dry Season					
Carabao	12	88	82	18	5	95	55	45	53	47
Carabao/thresher	13	87	87	13	-[c]	100	86	14	68	32
Two-wheel	9	91	74	26	6	94	70	30	63	37
Two-wheel/thresher	19	81	93	7	17	83	98	2	85	15
Two-wheel/carabao	19	81	91	9	-	100	100	-	82	18
Two-wheel/carabao/ thresher	24	76	92	8	16	84	100	-[c]	81	19

[a]Hired labor

[b]Family labor

[c]Considerably less than one hour

Table 9. Distribution of labor hours per hectare, hired and family labor, for various farm operations of non-mechanized and mechanized farms -- crop year 1979-1980.

Farm Classification	Land Preparation		Planting		Care/ Cultivation		Post production		Total Labor Hours		Total Labor Hours	Number of Household
	H[a]	F[b]	H	F	H	F	H	F	H	F		
Non-mechanized land preparation	24	99	187	41	2	31	187	75	400	246	646	203
Mechanized land preparation	10	35	177	17	3	25	186	19	376	96	472	216

[a]Hired labor

[b]Family labor

Table 10. Comparison of labor hours utilized by each farm-type during wet and dry seasons, crop year 1979-1980.

Farm Classification	Family Labor			Hired Labor			Total Labor		
	Wet Season	Dry Season	t value	Wet Season	Dry Season	t value	Wet Season	Dry Season	t value
Carabao	233	294	-1.0150	354	332	0.3168	587	626	-.04301
Carabao/thresher	231	251	-0.4521	366	544	-3.6239*	597	795	-3.3930*
Two-wheel	50	244	-1.5526	446	408	0.7499	496	652	-1.1385
Two-wheel/thresher	88	66	1.3201	355	368	-0.3744	443	434	0.2546
Two-wheel/carabao	128	96	0.9756	367	436	-1.1555	495	532	-0.7135
Two-wheel/carabao/ thresher	117	82	1.2968	375	351	0.5021	492	433	1.1834

*Significant at P = 1%.

Table 11. Comparison of labor hours utilized per hectare -- non-mechanized versus mechanized farms, crop year 1979-1980.

Farm Type	Land Preparation	Planting	Care/ Cultivation	Post production	Total Labor Hours	Number of Observations
Non-mechanized[a]	115	204	32	246	597	98
Mechanized[b]	74	211	29	228	542	321
t-value	4.0340*	-0.5127	0.5317	0.9372	1.5126	

[a]Farm using only carabao power (or C farms).

[b]Farms under this classification are: CT, TW, TWT, TWC and TWCT.

*Significant at α = 1%.

Table 12. Comparison of labor hours utilized per hectare -- farms utilizing only carabao power versus farms utilizing mechanical power for land preparation.

Farm Type	Land Preparation	Planting	Care/ Cultivation	Post-production	Total Labor Hours	Number of Observations
Non-mechanized land preparation[a]	124	226	32	261	643	203
Mechanized land preparation[b]	45	194	28	205	472	216
t-value	12.6835*	2.8908*	1.3269	3.7152*	6.5075*	

[a]Farms using only carabao power for land preparation.

[b]Farms using mechanical power (two-wheel tractor) or a combination of carabao and mechanical power.

*Significant at P = 1%.

Table 13. Comparison of family labor hours per hectare -- non-mechanized land preparation versus mechanized land preparation, crop year 1979-1980.

Farm Classification	Land Preparation	Planting	Care/ Cultivation	Post-production	Total Family Labor Hours	Number of Households
Non-mechanized land preparation	99	41	31	75	246	203
Mechanized land preparation	35	17	25	19	96	216
t-value	10.1688**	3.4412**	1.9274*	5.5035**	8.2428**	

**Significant at P = 1%.

*Significant at P = 10%.

Table 14. Comparison of hired labor hours utilized per hectare -- non-mechanized land preparation versus mechanized land preparation, crop year 1979-1980.

Farm Classification	Land Preparation	Planting	Care/ Cultivation	Post-production	Total Hired Labor Hours	Number of Households
Non-mechanized land preparation	24	187	2	187	400	203
Mechanized land preparation	10	177	3	186	376	216
t-value	3.8990*	0.8955	-0.8509	0.1082	1.0481	

*Significant at P = 1%.

Table 15. Comparison of labor hours utilized per hectare -- non-thresher users versus thresher using farms, crop year 1979-1980.

Farm Type	Post-production	Number of Observations
Non-thresher users	245.78	167
Thresher users	222.88	252
t-value	1.4235*	

*Significant at P = 1%.

Table 16. Estimated difference in labor use in rice production among farms with different modes of mechanization, crop year 1979-1980.

Independent variables	Total hired labor		Total family labor		Total labor	
	Model 1[a]	Model 2[b]	Model 1	Model 2	Model 1	Model 2
Intercept	-24.23 (-0.37)[c]	-37.01 (-0.63)	213.81** (6.64)	223.55** (7.82	183.81** (2.85)	182.65** (3.18)
Two-wheel (M_1)	-27.50 (-0.13)	-146.97 (-1.77)	-46.29 (-0.44)	-182.51** (-4.52)	-75.42 (-0.35)	-37.61 (-0.46)
Two-wheel/ carabao (M_2)	-10.89 (-0.10)	58.89 (0.79)	-128.86* (-2.35)	-147.50** (-4.04)	-141.27 (-1.29)	-89.59 (-1.22)
Two-wheel/ thresher (M_4)	92.39 (0.77)	-47.19 (-0.80)	-72.20 (-1.23)	-134.83** (-4.68)	17.94 (0.15)	-185.13** (-3.20)
Two-wheel/carabao/ thresher (M_5)	-57.95 (-0.57)	-8.04 (-0.12)	-150.12* (-3.01)	-155.32** (-4.85)	-209.23 (-2.09)	-164.96** (-2.56)
Seasonal effect (S)	14.16 (0.17)	17.55 (0.39)	-55.14 (-1.35)	-47.96* (-2.19)	-34.28 (-0.42)	-28.89 (-0.66)
Irrigation (I)	48.11 (0.77)	55.88 (1.22)	-29.91 (-0.98)	-55.62* (-2.48)	17.23 (0.28)	0.19 (0.004)
Tenure (T)	-10.37 (-0.23)	-1.85 (-0.04)	-1.31 (-0.06)	-1.68 (-0.08)	-11.93 (-0.28)	-4.10 (-0.10)
Area (A)	367.55** (15.75)	368.27** (18.22)	72.62** (6.38)	72.55** (7.36)	443.66** (19.45)	443.45** (22.41)

[a]Non-additive model
[b]Additive model
[c]Values in parentheses are calculated t-values
**Significant at P = 5%
*Significant at P = 1%

- more -

Table 16 cont'd.

Independent variables	Total hired labor		Total family labor		Total labor	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
IM_1	200.09 (0.85)		-165.32 (-1.44)		34.84 (0.15)	
IM_2	122.22 (0.81)		-38.21 (-0.52)		85.76 (0.58)	
IM_4	-163.19 (-1.24)		-78.85 (-1.23)		-241.28 (-1.88)	
IM_5	86.86 (0.65)		-6.92 (-0.11)		80.81 (0.62)	
SA	-3.98 (-0.10)		-4.17 (-0.20)		-11.23 (-0.27)	
R^2	0.51	0.51	0.23	0.23	0.60	0.59
F-value[d]	32.82	52.91	9.45	15.03	46.14	74.26
No. of observation	419	419	419	419	419	419

[d]F-statistic for testing the significance of the regression model.

Appendix Table 1. Selected characteristics of the different types of farm households in eight villages in Cabanatuan City and Guimba, Nueva Ecija, 1979 wet season.

Items	Type of farm household					
	Carabao	Carabao/ thresher	2-wheel	2-wheel/ thresher	2-wheel carabao	2-wheel/carabao/ thresher
Number of households	72	58	21	41	31	27
Demographic characteristics						
Ave. age of household head (yrs.)	41.77	42.58	44.41	47.63	43.14	43.69
Ave. education of household head (yrs.)	4.32	4.58	4.03	4.14	5.14	4.79
Ave. experience in farming (yrs.)	18.28	19.36	24.05	21.00	19.68	16.04
Ave. number of household members	5.50	5.45	5.52	5.88	5.74	5.00
Land characteristics						
Ave. size of farm holding (has.)	1.85	2.14	2.57	2.66	2.07	1.94
Ave. rice crop area (has.)	1.52	2.05	2.50	2.63	1.98	1.94
Tenure status						
Owner (%)	48.6	63.8	28.6	17.1	61.3	50.0
Part-owners (%)	4.2	3.5	4.7	7.3	6.5	10.7
Lessees (%)	29.1	17.2	66.7	70.7	29.0	21.4
Share-croppers (%)	4.2	-	-	-	-	3.6
Others (%)	13.9	15.5	-	4.9	3.2	14.3
Average yield (kg/ha)						
Rice-traditional	1,131	872	-	-	-	-
Rice improved	2,185	4,043	4,099	3,854	2,721	2,848

Appendix Table 2. Selected characteristics of the different types of farm households in eight villages in Cabanatuan City and Guimba, Nueva Ecija, 1980 dry season.

Items	Type of farm household					
	Carabao	Carabao/ thresher	2-wheel	2-wheel/ thresher	2-wheel/ carabao	2-wheel/carabao/ thresher
No. of households	26	47	11	54	6	25
Demographic characteristics						
Ave. of age of household head (yrs.)	40.81	40.09	36.55	47.24	42.00	44.32
Ave. education of household head (yrs.)	4.12	4.91	4.00	3.81	6.67	4.96
Ave. experience of household head (yrs.)	18.92	15.89	14.36	21.76	16.83	19.36
Ave. number of household members	5.69	5.83	5.27	5.76	6.83	5.44
Land characteristics						
Ave. size of farm holding (has.)	1.40	1.71	1.58	2.38	2.68	1.88
Ave. rice crop area (has.)	0.82	0.91	1.46	2.32	1.49	1.96
Tenure status						
Owner (%)	61.6	42.6	27.3	29.6	66.7	40.0
Part-owners (%)	-	-	-	3.7	-	4.0
Lessees (%)	11.5	46.8	54.5	59.3	33.3	40.0
Share-croppers (%)	7.7	4.2	-	-	-	-
Others (%)	19.2	6.4	18.2	7.4	-	16.0
Ave. yield (kg/ha)						
Rice-traditional	-		-	-	-	-
Rice-improved	2,505	4,199	4,336	4,173	3,541	4,546

Appendix Table 3. Comparison of labor hours utilized per hectare among farms using mechanical power for land preparation, crop year 1979-1980.

Farm Type	Land Preparation	Planting	Care/ Cultivation	Post-production	Total Labor Hours	Number of Observations
Two-wheel	40	214	26	270	550	32
Two-wheel/thresher	35	194	28	182	439	95
Two-wheel/carabao	61	186	31	223	501	37
Two-wheel/carabao/ thresher	55	188	27	194	464	52
F-value	8,5713**	0.6249	0.3440	4.2879**	2.8933*	

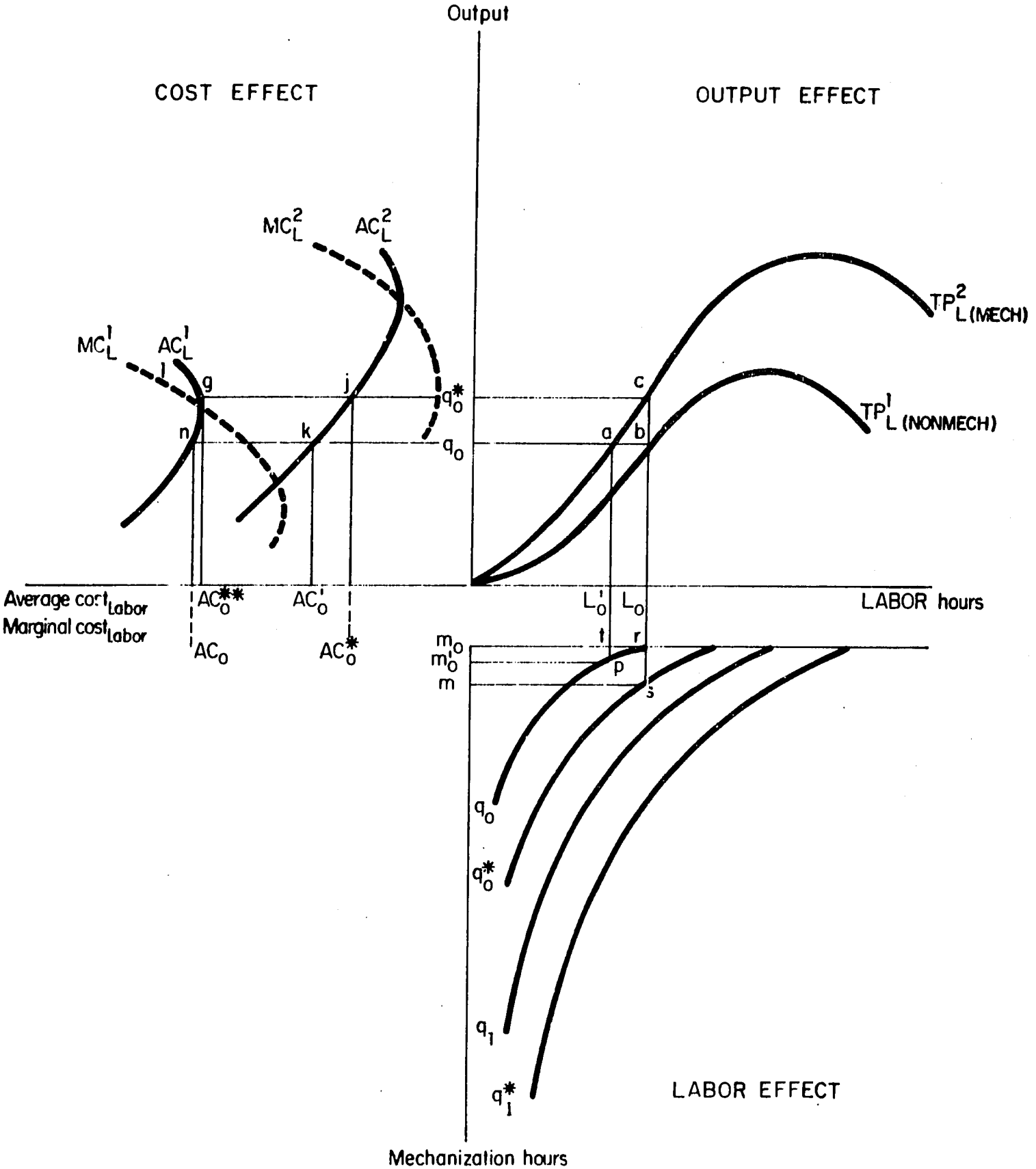
**Significant at P = 1%.
*Significant at P = 5%.

Appendix Table 4. Comparison of family labor hours utilized per hectare among farms using mechanical power for land preparation, crop year 1979-1980.

Farm Type	Land Preparation	Planting	Care/ Cultivation	Post-production	Total Family Labor Hours	Number of Households
Two-wheel	36	22	23	36	117	32
Two-wheel/thresher	29	15	24	8	76	95
Two-wheel/carabao	43	24	30	26	123	37
Two-wheel/carabao/ thresher	38	13	24	25	100	52
F - value	0.1432	0.1704	0.2242	0.3826	0.2717	

Appendix Table 5. Comparison of hired labor hours utilized per hectare among farms using mechanical power for land preparation, crop year 1979-1980.

Farm Classification	Land Preparation	Planting	Care/ Cultivation	Post-production	Total Hired Labor Hours	Number of Households
Two-wheel	5	191	3	234	433	32
Two-wheel/thresher	6	179	4	174	363	95
Two-wheel/carabao	18	162	1	197	378	37
Two-wheel/carabao/ thresher	16	175	3	169	363	52
F - value	0.8759	0.2830	0.3315	1.0935	0.5117	


Output
COST EFFECT
OUTPUT EFFECT
MC_L^2
AC_L^2
MC_L^1
AC_L^1
$TP^2_{L\,(MECH)}$
$TP^1_{L\,(NONMECH)}$
l
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Average cost$_{Labor}$
Marginal cost$_{Labor}$
AC_o^{**}
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LABOR EFFECT
Mechanization hours

Figure 1

36

CONSEQUENCES OF SMALL RICE FARM MECHANIZATION PROJECT

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