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THE CONSEQUENCES OF SMALL RICE FARM MECHANIZATION PROJECT

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A GENERAL EQUILIBRIUM ANALYSIS OF THE EFFECTS OF RICE FARM MECHANIZATION IN THE PHILIPPINES

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ABSTRACT

A macroeconomic model, with semi-closed input-output relations, is used to compare employment, income distribution, and resource utilization effects of producing additional rice using alternative rice farm mechanization systems. Aggregate net effects are computed by incorporating 'factor intensity', 'distribution', 'consumption', and 'import substitution' effects. A methodological step involved disaggregation of the conglomerate production vector for rice and agricultural machinery sectors into sub-sectors depending on water control-topography-technology mix and individual machine groups respectively. Five household classes are distinguished to provide some variation in consumption, savings and import behaviour. The simulations consider m subsets of the final demand vector for rice. Results indicate the effects of mechanization vary widely among four water-topographical regimes considered in the model. While increasing intensities of mechanization in a given water regime is found to worsen employment and income distribution problems, a comparison among water regimes indicate positive results of increasing water control.

INTRODUCTION

The mechanization of a traditional agricultural system may produce substantial indirect effects on other sectors of the economy, particularly where agriculture contributes a significant share of GNP and where farm mechanization becomes relatively widespread. The indirect effects, exemplified in the concepts of 'forward' and 'backward' linkages, stem from production and consumption interactions of the agricultural sectors with the non-agricultural sectors. The production effects arise as mechanized farm production generates demand for agricultural machinery whose production in turn generates demands for engines, steel, bearings and manufacturing labor. Consumption effects originate either when there is flow of extra income from mechanization or when it leads to a redistribution of existing income. On both accounts, there are changes in the level of final demand in the economy. The production and consumption effects together may lead to changes in macro-aggregates like employment, income distribution, consumption and savings. Knowledge of these macro effects may help policy makers choose between alternative mechanization strategies in terms of their impacts on output, employment, income distribution and savings. With knowledge of the relative strength and incidence of the linkages, planners can pursue policies to achieve the desired objectives. Finally, the macro effects may give insights into possible problems that may occur when mechanization increases industrial income, thereby causing an increase in rural-urban income disparity.

Most past studies of farm mechanization effects measured the micro or direct effects of mechanization to specified farm units. Such 'micro' approaches ignore subsequent reactions in the industrial sectors and hence suffer from the standard limitations of a partial equilibrium analysis. However, without taking into account the changes in employment, income distribution and production in all sectors of the economy, both the direct effects of mechanization and the feedback effects of resulting changes in total output and income, it is not possible to make valid, *a priori* judgements about the consequences of mechanization for the whole economy.

Our paper has the objective of measuring the magnitude and incidence of direct and indirect effects of alternative rice farm mechanization strategies. In particular, we use a general equilibrium macroeconomic model, with an input-output core, for measuring employment income distribution and resource utilization implications of rice-farm mechanization in the Philippines. We first set out our theoretical framework, then explain the considerations influencing our choice of methodology, next we present the macro-model along with the data set on which quantitative analysis are based, and finally present our results.

THEORETICAL FRAMEWORK

The indirect effects of farm mechanization are those that occur in sectors other than farm production. The input-output system developed by Leontief (1951, 1966) provides a framework for such a general equilibrium evaluation of the consequences of farm mechanization. Leontief's model recognizes the interdependence of industries in the economy that arises from the fact that each industry employs the outputs of other industries as its raw materials. Its output, in turn, is often used by other producers as a productive factor, sometimes by those very industries from which it obtained its ingredients. Tractors are used to produce rice, and tractors, in turn require rubber, steel and electricity. In a 'third round', rubber may require tractors and so on, ad infinitum.

The Leontief system uses an input-output table to describe the flow of goods and services within the economy over a given year. Each row shows the deliveries made by the sector associated with that row to all other sectors of the economy (including itself) and to final users. Each column shows the amount of input required and primary costs involved in the production process associated with that column. Primary costs represent 'value added' (income earned) by labor, capital and other primary factors and the sum of 'value added' is total GNP. The input-output table gives rise to a set of linear equations wherein lies the power of the input-output model. It can be used to quantify the direct and indirect transactions required to meet a given increase in direct consumption of commodities by consumers. In matrix notation, the input-output system can be expressed as $x-Ax=y$, where A is the square interindustry section of the technological coefficients (showing input requirements per unit of output), x is the column vector of total output and y is the column vector of final demand. Rearranging the linear equations, we get, $x = (I-A)^{-1}y$. The coefficients of the inverted matrix show direct and indirect production requirements to meet a given increase in final demand.

The indirect effects arising from farm mechanization are the results of interactions between agriculture and non-agriculture in production and consumption. Production effects arise from production linkages. Mechanized rice production generates a demand for intermediate inputs and machinery. Meeting these demands generates direct and indirect demand for labor. The magnitude of the labor demand depends on the labor intensity of production of rice (direct), farm machinery (indirect, first round) and the production process used in obtaining the machinery that produces farm machinery (indirect, second round). There are also consumption effects arising from consumption linkages. The extra income resulting from mechanization boosts the level of final demand of those receiving the income in the economy. The magnitude and incidence of the consumption effects depend on the consumption pattern of household classes. Thus, if a certain household class' consumption behavior is biased in favor of labor intensive commodities, and if it is the main beneficiary of change, a mechanization strategy would tend

to have greater impact on indirect employment.[1/] An obviously related factor is the income distribution pattern of household classes. Mechanization is likely to change value added in gross output, and depending on how the additional value added is distributed to wages and profits, laborers or entrepreneurs are better off.[2/] The final factor that influences the indirect effects is the import substitution pattern in consumption and production. Thus, on the consumption side, if laborers are net gainers from mechanical change and consume less imported products, domestic employment is greater.[3/] Similarly on the production side, if a certain mechanization program embodies less imported inputs, domestic employment would be correspondingly higher. It is the net effect of all of the above mentioned factors that translate the change in degree of farm mechanization to a change in employment, income distribution and savings.

The above discussion brings out the complex system of interactions that affect the total impact of meeting final demand using alternative technologies. The model used in the study incorporates 'intensity', 'distribution', 'consumption', and 'substitution' effects in arriving at the macro-economic consequences of rice farm mechanization.

METHODOLOGICAL CONSIDERATIONS

In order to reflect relevant alternative mechanization strategies, and to capture their direct and indirect effects, 13 rice production systems or subsectors are defined, differing by level of farm mechanization and associated water-topographical regimes. Similarly, the agricultural machinery sector is separated into 5 sub-sectors corresponding to individual machine groups and equipment. Descriptions of the rice and agricultural machinery sub-sectors are provided in Tables 1 and 2 respectively. The disaggregation of the rice and agricultural machinery sectors are designed to facilitate comaparison of various strategies of rice farm mechanization that may occur under various water regimes.

1/ Mellor, 1976. stresses the consumption effects in a somewhat broader development context.

2/ Johnson, 1954, elaborates on the effects of income redistribution on consumer's expenditure.

3/ ILO (1970) emphasizes the importance of import substitution in consumption as a determinant of employment.

The operation of our model proceeds on the basis that the exogenous demand for rice can be satisfied from the production by any of the 13 rice systems. Sp-cifying which system will produce what amount of final demand, the model uses semi-closed inout-output relations to compute domestic production and intermediate imports required to meet the demands. The factor shares of production then determine income distribution among owners of factors which in turn affects the volume and pattern of private consumption, direct imports for private consumption and savings. Finally, the model computes, for the new private consumption and income distribution, the corresponding gross output, employment, personal income, savings and imports.

The disaggregation of rice and agricultural machinery sector produces an input-output table of 46 x 46 sectors from the original 30 x 30 sectors breakdown of the 1978 Input-Output table of the Philippines.[4/]

4/ The 1978 I/O table (NEDA, 1978b) is an updated version of the 1974 I/O table reported in NEDA (1974).

The augmented matrix (46 x 46) had to meet two criteria: first, the individual technological coefficients corresponding to the rice and farm machinery sub-sectors had to be consistent with known differences among them. Secondly, the individual technical coefficients of sub-sectors had to aggregete into a conglomerate technological coefficient (for rice or farm machinery) equal to the sectoral coefficient that appears in the original input-output table.

The following illustrates the relationships between the aggregated and the separate technological coefficients.

(1) $$X = \sum_{i=1}^{13} x_i \; ; \qquad Y = \sum_{i=1}^{13} y_i$$

Then

$$A = \frac{Y}{X} = \frac{\Sigma y_i}{\Sigma x_i} = \frac{\Sigma a_i x_i}{\Sigma x_i}$$

$$= \Sigma a_i \frac{x_i}{\Sigma x_i}$$

$$= a_1 \frac{x_1}{\Sigma x_i} + a_2 \frac{x_2}{\Sigma x_i} \; . \; . + a_{13} \frac{x_{13}}{\Sigma x_i}$$

or, equivalently

(2) $$A = a_1 w_1 + a_2 w_2 + \; . \; . \; . \; + a_{13} w_{13}$$

X is aggregated output transaction in value terms

x_i are disaggregated output transaction in value terms

Y is aggregated input transaction

y_i are disaggregated input transaction

A is the aggregated technological coefficient

a_i are the disaggregated technological coefficient

w_i are the sub-sectoral weights expressing proportion of rice produced under each system.

The above derivation shows that the aggregated technological coefficient for rice appearing in the input-output table is the weighted average of the separate sub-sectoral coefficients. This relationship provides a convenient method of consistently estimating the sub-sectoral vectors from the original conglomerate vector. The same principle applies for disaggregating the agricultural machinery sector.

Two remarks need to be made here. First, since the sub-sectoral technological coefficients were obtained from farm level surveys, the right hand side of equation (2) did not automatically conform to the left hand side. In cases of such inequality, we attempted to solve the problem by proportional changes in the sub-sectoral technological coefficients. Second, because we are concentrating on the consequences of farm-level mechanization we ignore the differential impacts which might originate from the use of different post-threshing and milling techniques. Hence we assume that the technological coefficients of inputs in the post-threshing and milling stages are the same for all paddy production systems.

In the model, we distinguish between five household classes to incorporate the income distribution, consumption, saving and import substitution effects of farm mechanization. While for rice farm households, our definitions rest on factors of payments criteria, namely endowments of land, labor and capital, the definitions of remaining households depen on types of activities performed. Among the five household classes, the first three belong to the rice sector.

i) hired labor households
ii) operator households
iii) landowner households
iv) non-rice farm households
v) non-farm households.

The hired labor households derive their income from offering labor services to rice farmers. Landowner households include farmers as well as landlords. Their income consists of the returns from land and capital. The farm operator households are renters of land and they obtain earnings from both capital and labor. Incomes of non-rice farm and non-farm households are assumed to depend on gross output produced in these sectors.

The inclusion of these five sets of households provides a mechanism within the model to reflect variation in consumption, saving and import behavior by the population classes directly affected by rice farm mechanization. The separation of farm and non-farm households allows us to measure changes in rural-urban income distribution caused by a alternative mechanization programs.

The model calculates total savings available under different rice production systems. Differences in savings behavior among household classes combined with differential changes in household incomes account for changes in the saving rate.

Imports are separated into two kinds: imports for intermediate uses and imports for final consumption. Intermediate imports depend on production linkages while imports for final uses are determined by consumption linkages.

Private consumption of each commodity is divided among the household classes in accordance with their consumption behaviors. The model distinguishes consumption of domestic from imported items, but due to lack of data, consumption imports are not separated into individual items but allocated as a whole to each of the household classes.

DESCRIPTION OF THE MODEL

We begin with a set of material balances among n production sectors and h household classes.

$$(3) \qquad X_i = \sum_{j=1}^{n} a_{ij}X_j + \sum_{k=1}^{h} c_{ik}Y_k + F_i$$

where

X_i denotes the gross output of sector i

a_{ij} the input value of commodity i needed to produce a unit value of commodity j

c_{ik} is the expenditure coefficient of household class k on commodity i

Y_k is the income of household class K

F_i is other final uses of commodity i including such items as government consumption expenditure, gross domestic capital formation, exports and imports.

Since consumption purchases are made dependent on the level of income of the particular group, F_i represents an exogenous variable of the model whose value can be changed at will to conduct policy exercises.

Total import is disaggregated by two groups: import for intermediate use and import for consumption.

$$(4) \qquad M = \sum_{j=1}^{n} a_{mj} X_j + \sum_{k=1}^{h} c_{mk} Y_k$$

where

M is the value of total import

a_{mj} is the value of intermediate imports needed to produce a unit value of commodity j

c_{mk} is the expenditure coefficient of household class k on imports.

Total savings are obtained by summing savings of various income groups.

$$(5) \qquad S = \sum_{k=1}^{h} c_{sk} Y_k$$

where

S is total savings

c_{sk} is the savings propensity of income group k.

Gross value added in each of the rice systems is separated into payments to hired labor, payments to operators and payments to landlord. These payments determine income for the first, second and third group of our household classes. Non-rice farm income and non-farm income are assumed to be fixed portions of total output in these sectors.

Thus, income for the population class k can be expressed by the following equation.

$$(6) \qquad Y_k = \sum_{j=1}^{n} a_{kj} X_j$$

where

a_{kj} is income component generated for household class k per unit of commodity j produced.

Finally, total labor requirements in the economy are obtained by summing labor requirements of all the n industries:

$$(7) \qquad L = \sum_{j=1}^{n} a_{1j} X_j$$

where a_{1j} is labor coefficient.

The following relationships hold in our model:

$$\sum_{i=1}^{n} c_{ik} + c_{mk} + c_{sk} = 1$$

The relationships (3-7) can be presented as follows:

$$(3') \qquad X(I-A) - C_c Y_k = F$$

$$(4') \qquad -XA_m - C_m Y_k + M = 0$$

$$(5') \qquad - C_s Y_k + S = 0$$

$$(6') \qquad -XA_k + Y_k = 0$$

$$(7') \qquad -XA_1 + L = 0$$

where

X is vector of outputs with dimension 46 x 1

A is the square matrix of size 46 x 46 of input coefficients

C_c is a rectangular matrix of size 46 x 5 of domestic consumption coefficients c_{ik} of 5 household classes

Y_k is a vector of household class incomes with dimension 5 x 1

F is vector of other final uses with dimension 46 x 1

A_m is a row vector of import coefficients a_{mj} of size 1 x 46

C_m is a row vector of private consumption for imported goods a_{mk} of size 1 x 5

M is total imports

S is total savings

C_s is a row vector of private savings c_{sk} of size 1 x 5

A_k is a rectangular matrix of size 5 x 46 of income coefficients

A_l is a row vector of size 1 x 46 of labor coefficients

L is total labor requirements

Expressing in matrix notation, we have

$$\left[\begin{array}{c|c|c|c} I-A & 0 & -C_c & 0 \\ \hline \begin{matrix} -A_m \\ 0 \end{matrix} & I & \begin{matrix} -C_m \\ -C_s \end{matrix} & 0 \\ \hline -A_k & 0 & I & 0 \\ \hline -A_l & 0 & 0 & I \end{array}\right] \left[\begin{array}{c} X \\ \hline \begin{matrix} M \\ S \end{matrix} \\ \hline Y_k \\ \hline L \end{array}\right] = \left[\begin{array}{c} F \\ \hline \begin{matrix} 0 \\ 0 \end{matrix} \\ \hline 0 \\ \hline 0 \end{array}\right]$$

or $Q.R = S$

where Q is a square matrix of size 54 x 54 pertaining to structural coefficients

R is a column vector of the endogenous variables of size 54

S is a column vector of the exogenous variables of size 54

The solution is therefore

$$R = Q^{-1}S$$

The elements on the main diagonal of matrix are positive. Moreover, remaining non-zero elements are negative and, with the exception of the import coefficients, are smaller than one. We can therefore expect that matrix Q must have an inverse.

To isolate the effect of farm mechanization, we simulate the model by considering the effect of a 1% increase in final demand for rice satisfied from each of the production systems in turn, that is, we consider m subsets of final demand vectors. Each vector contains one positive element for the system by which a given quantity of rice is produced, while the rest of the elements are taken to be zero. In each case, the vector of endogenous variables generates:

1) direct and indirect employment
2) income distribution
3) savings
4) import
5) direct and indirect requirements of inputs.

The model shows what the equilibrium state of the economy looks like under alternative states of rice farm mechanization. The total impact on the economy is calculated not only as the sum of (a) labor intensity, (b) consumption, (c) income distribution, and (d) import subsitution effects, but also as the feedback effects of resulting changes in total output. The exercise is a static comparative simulation of additional rice production from 13 alternative systems of rice production corresponding to different assumptions about water control, topography and degree of mechanization. We use a system of exclusively linear homogenous equations which allows us to obtain solutions by simple matrix inversion operation.

The most important limitations of the model are the assumptions of Leontief's linear homogenous production function, constant returns to scale and no economies of scale, free labor force resources and no capacity limitations, and no balance-of-payment limitations.

DESCRIPTION OF DATA

The data required by the model were obtained from various sources and are described below. Some of the data were not available and were estimated.

Rice production systems

The model distinguishes among the 13 systems of rice production identified in Table 1. In three of the four kinds of water-topographical regimes (gravity, pump, rainfed) land preparation and threshing are carried out using various degrees of mechanization. The upland system is non-mechanized. The following cropping intensity indices are assumed: gravity 133%, pump 200%; rainfed 105%; upland 85%.

Three alternative techniques of land preparation are available: carabao (water buffalo), power tiller, and tractor. It is recognized that some farmers may combine two of the above techniques for land preparation in their farms. Three threshing techniques are included: manual, portable and large axial flow thresher. In Table 1, the rice production systems are arranged in ascending order of mechanization within a given water regime. The first involves zero level of mechanization, the fourth a fully mechanized system while the second and third represent intermediate technologies.

The quantity data on gravity systems were obtained from Herdt and Lacsina (1976). The price data for 1978 were obtained from the Bureau of Agricultural Economics (BAECON). The source of farm data was a survey of Central Luzon and Laguna farmers carried out by the Economics Department of the International Rice Research Institute (IRRI) in 1975.

Pump irrigation systems are gaining popularity throughout the Philippines and are widespread in Laguna. Data for the Laguna irrigation system were obtained from Herdt and Lacsina (1976) based on a survey of Laguna farms in 1973-74.

Rainfed farming is widespread in Bicol and Iloilo regions. Our data on rainfed areas were obtained from a 1977 survey of Iloilo reported by Herdt and Gonzales (1980).

Upland systems comprise 11 percent of total rice area and is most prevalent in Cagayan Valley, Southern Tagalog, Bicol, Western Visayas, Eastern Visayas, Southern and Northern Mindanao. The data on upland rice production systems were based on a 1973 survey by Dozina and Herdt (1974).

A budget was developed for each of the rice production systems, showing the breakdown of costs and the earnings accruing to hired labor, operator, and landowner. The budgets appear in Appendix A. Total value of output was allocated to intermediate inputs, labor earnings, return to land, taxes and operator's residual. Within the intermediate inputs, machinery was separated from the other sectors (seed, carabao, fertilizer other chemicals, fuel and lubricants).

Cost of agricultural machinery use was separated into (i) depreciation, (ii) returns to capital, (iii) fuel and lubricants, (iv) repair and (v) labor costs.[5/] Repair costs were assumed to consist half of labor cost with the other half distributed to depreciation and returns to capital in the same proportion as for the original machine. Capital consumption allowance includes returns to capital for both the machinery and the spare parts plus interest charges.

Once the returns to land, labor and capital had been calculated, they were apportioned to household classes in the following manner. Landowner's income equals rent on land, 50 percent of capital consumption and family labor allowances. Income of hired labor households is the value added by hired labor. The income of operator households correspond to the residual 50 percent of capital consumption and family labor allowances. Indirect taxes are subtracted from each cost component and aggregated to show indirect taxes collected from rice production. Tax and tafiff rates on agricultural inputs and machinery were obtained from tariff and customs code of the Philippines.

The model requires the current proportion of paddy produced under each of the rice production systems. Though data is available on amount of paddy grown under each water-topographical regime, its breakdown into different levels of mechanization is not available. We arrived at these figures in two stages. In the first step, we estimated the proportion of paddy area under mechanization and proportion of paddy mechanically threshed, and in the second step, we allocated the two proportions to various water and topographical regimes in a consistent manner. The proportions of rice produced under various systems are indicated in Appendix A. For estimating the proportion of rice area by type of mechanization, we depended on BAEcon (1976) survey of agricultural machinery. The survey found that 25,939 power tillers and 12,957 tractors were in use in the agricultural sector. Based on sales figure published by Agricultural Machinery Manufacturers and Distributors Association (AMMDA) 92% of power tillers and 47% of tractors were used in rice production. Studies conducted by IRRI Engineering Department (Orcino 1972; Orcino and Duff 1973) found that on average power tillers and tractors are used for 440 and 1400 hours respectively in a year. These studies also found that power tillers and tractors require 25 hours and 5 respectively to plough one hectare. Since the BAEcon survey counted agricultural machinery irrespective of their productive life spans, we made an assumption of 50% utilization levels for the aggregate stock of agricultural machinery used in

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[5/] The assistance of the IRRI Agricultural Engineering Department in this is appreciated.

paddy production. These figures together indicate that 1.06 million hectares or 28% of total national rice area is under mechanization. This area is allocated among various water regimes in the following manner. Fifty percent of the area in pump and gravity irrigation systems use power tillers or tractors, 15% of rainfed system use them while upland systems use only carabao.

For estimating the proportion of paddy which is mechanically threshed we relied on unpublished data of the National Grains Authority (NGA) which found 11,500 threshers in 1979. Field interviews by the IRRI Engineering Department showed that the IRRI designed axial flow thresher (old model) was used for 500 hours per year and the portable (old model) thresher was used 300 hours in a year. The interviews with farmers also showed that 1.5 hours of machine time was required to thresh one ton of paddy by large axial flow thresher and 2.5 hours was required by the small thresher. With the assumption of 50% utilization, it appears that 1.38 million tons or nearly 20% of the total paddy was mechanically threshed. This total was allocated to different water regimes in the following manner: 40% of pump and gravity irrigated rice was mechanically threshed, 7% of rainfed rice and 0% of upland rice.

Paddy yield is assumed to depend on water availability and topography for a given variety of seed. Mechanization does not affect yield.

Agricultural machinery sub-sectors

The model uses a 5 sub-sectoral breakdown of the agricultural machinery sector into power tiller, tractor, irrigation pump, portable and large axial plow threshers (Table 2). For each of the machines, a budget was developed showing intermediate and primary costs involved in their construction (Appendix B). The cost data were obtained from the industrial extension unit of the IRRI Engineering Department.

Three sectors supplied materials to agricultural machinery -- basic metal and purchased material, paints and chemicals and rubber products. Small machines like power tillers, threshers, and irrigation pumps are domestically manufactured with imported engines, while four-wheel tractors are imported on either partly knockdown (PKD) or a completely knockdown (CKD) basis.

Labor costs refer to total compensation of employees, while the cost categorized as other is residual item showing profit, dealer's margin, returns to capital and interest charges.

Information on tax and tariff rates were obtained from the Tariff and Customs Code of the Philippines.

The same procedure as utilized in the rice production sector was used for consistently seggregating the conglomerate technological coefficient of the agricultural machinery sector into separate subsectors,

namely, power tillers, tractors, irrigation pumps, portable and axial flow threshers.

The weights or the proportion of capital asset under each of the machinery sector is estimated from existing number of machineries in each of the subsectors.

Input-Output Table

The 63 sector classification of 1978 Input-output table of the Philippines constructed by the National Economic and Development Authority (NEDA) was our basic source of intersectoral transactions. It provides sectoral information on value added by primary factors, indirect taxes less subsidies, private and government consumption expenditure, domestic capital formation, exports and imports.

For the purposes of our model, the original input-output table of 63 sectors was aggregated into one with 30 sectors (Appendix C). The 30 producing sectors, that are distinguished for the purposes of the model, include a combined rice milling and paddy production (sector 1), other agriculture (2 and 3), mining (4), food processing (5 and 6), consumption and intermediate goods (7-15), capital goods (16-20), supply goods (21-25) and services of diverse nature which are sufficiently explained by their titles (26-30).

Consumption Expenditure

The data on consumption expenditure patterns of household were obtained from 1975 Family Income and Expenditure Survey of National Census and Statistics Office (NCSO). Five household classes are assumed to correspond to five income classes; landowners to income range ₱8,000 - 10,000 which is income of the highest 10% of rural households; operators to income range ₱3,000 - 4,000 which is income of the median group of rural households; hired labor to income range of ₱1,000 - 1,500 which is income of the lowest 10% of rural households; non-rice farm households to income range ₱4,000 - 5,000 which is income of average rural households and nonfarm households to income range ₱6,000 - 8,000 which correspond to average income of urban households. The model requires us to distinguish consumption expenditures on each item by household classes. For this purpose, consumption items were first aggregated from the original 45 sectors of the 1975 Family Income and Expenditure survey into a 30 sector breakdown to correspond to 1978 Inout-Output Table. For durable agricultural machineries like power tiller, tractor, pumps and threshers, consumption purchases signify investment spending on these machineries. Investment behavior of rice-farm household classes is assumed to be identical to their savings behavior.

Imports

The import data are available from 1978 Foreign Trade Statistics of the Philippines published by NCSO. Information on imports for intermediate uses by sectors were obtained from the 1978 input-output accounts of the Philippines. The model requires data on import propensities of consumption for different household classes. Since such information were not available, we estimated them from other sources like the 1975 Family Income and Expenditure Survey. The estimation procedure involved three steps. In step 1, we calculate aggregate import propensity from information on total import for consumption and national income. In step 2, we estimated the shares of major consumption items which involve a high percentage of imports like clothing and footwear, fuel and light, rubber and chemical products, medical care and recreation in the households income. In step 3, we consistently allocated the aggregate import propensity among various household classes. The above procedure yields only approximate estimates of the import propensities by income groups but nevertheless they serve our purpose.

Savings and Taxes

Savings and taxes include personal plus corporate savings and direct plus indirect taxes. Data on aggregate savings and taxes are obtained from the publication by NEDA entitled National Income Accounts 1978. The aggregate savings and tax figures are disaggregated into separate household classes of our model. The savings rate in the rice production sector is assumed to equal that of rural households savings rate calculated to be 9.1% (R. Bull 1977). The 1975 Family Income and Expenditure survey is utilized for disaggregating rural savings and tax rates to different household classes.

Labor Force

Data on labor force are taken from survey of households bulletin (1978) of the National Census and Statistics Office. The data include both unemployed and employed labor force. Payroll per employed person is found by dividing total compensation of employees by labor force.

SIMULATION OF THE MACRO-ECONOMIC MODEL AND CALCULATION OF RESULTS

In order to demonstrate the potential of the model, we simulated the impact of a one percent increase in consumer spending for rice, so that in each simulation the additional consumer demand is fully met from a specific system of rice production. The simulation involved post-multiplying the inverted matrix with the final demand vector (F) reflecting the one percent increase in consumer spending for rice. In each case, the vector of endogenous variables generate increase in direct and indirect employment, rise in income by household classes, increase in savings and imports. For calculating the additional requirement of inputs, it became more realistic to consider a one percent increase in rice production rather than one percent increase in consumer spending but again supply is assumed to be met from the specific rice production sector. One percent of total consumer spending for rice was found to equal ₱99.3 million with purchase capacity of 45.2 thousand tons of milled rice or 76.5 thousand tons of rough rice (palay). One percent of rice production was almost the same -- 45.5 thousand tons of milled rice or 76.7 thousand tons of rough rice (palay) with gross value of ₱190.1 million. The results are summarized below in terms of employment, resource requirements, income distribution within the rice economy and among household classes, and income, consumption, savings and imports.

Employment

Employment refers to the total labor force employed and is calculated by dividing compensation of employees by weighted average payroll per employee. The direct effect of employment are a reflection of the labor/output ratios appearing in budget studies, the indirect effects a reflection of labor use in industries that are related to rice production by 'backward' and 'forward' linkages, taking into account both the production and consumption effects.

The results are shown in Table 3. Total employment in the economy as it operated in 1978 is estimated at 16.968 million. The data in column (1) show total employment if a 1% increase in rice production is met from each specified sector in turn. Column 2 shows the increased employment.

The results indicate that pump irrigation systems provide the greatest potential for employment increases -- 37 to 55 thousand worker increase -- followed by gravity, rainfed and upland systems. Within a given water regime, employment falls with higher degrees of mechanization, but within a mechanization level employment rises with higher degrees of irrigation. If one compares the impact using mechanized techniques of rice production under gravity or pump systems (36/37 thousand increase) with traditional technique under rainfed (31 thousand) and upland (18 thousand) it is evident that even the least labor intensive irrigation system absorbs

more labor than the most labor intensive rainfed system. Thus low productivity due to lack of water control and inadequate inputs rather than mechanization per se is responsible for low employment. As expected, the direct or on-farm employment usually declines with greater intensity of mechanization (col. 3) and accounts for 50-80% of total (direct and indirect) decline of employment in a given water regime. On the other hand, indirect employment (col. 4) is little affected by increases in the intensity of mechanization, except in the rainfed case and in the most highly mechanized system. The failure of indirect employment to increase under rainfed cultivation and in fully mechanized systems is probably due to redistribution of income to households with low consumption and high import propensities. The ratio of indirect/direct employment effect rise with increases in the intensity of mechanization under all regimes (col. 5) pointing to the fact that linkages assume a greater role under mechanization. Finally, the results show, not surprisingly, that micro-studies using on-farm employment data overestimate the net displacement of labor in all except the fully mechanized systems in irrigated regimes. Furthermore, it is observed that the greater is the intensity of mechanization larger is the overestimation. On the other hand, under rainfed cultivation and in the fully mechanized systems on-farm employment data underestimates the true displacement of labor and here greater is the intensity of mechanization, smaller is the underestimation.

Resource Requirements

The resource requirements (direct and indirect) of sustaining the given increase in rice production from each source are reflected in "quasi-elasticities" derived from the model and interpreted like conventional elasticities. Because the quasi-elasticities were obtained from the solution of the general equilibrium model they indicate input requirements not only in the rice sector but also in the non-rice sectors that are related in a direct or indirect way. The quantitative values of the quasi-elasticities can be used by policy makers wanting a general equilibrium solution of the input requirements by all sectors of the economy.

The irrigated systems have relatively higher requirements of all the intermediate inputs as reflected in their higher quasi-elasticities. On the other hand, a 1% increase in rice production would require 61,000 ha of upland, 38,000 ha of rainfed, 25,000 ha of gravity irrigated or 19,000 ha of pump irrigated land.

The results in Table 4 show that mechanization leads to an increase in efficiency of individual input utilization as indicated by the decline in quasi-elasticities with increasing levels of mechanization. The greatest increase in efficiency for fertilizers and chemicals are derived with mechanization in rainfed conditions and for petroleum products with mechanization in pump irrigattion systems.

Petroleum products and carabao services enter households' consumption functions either in a direct or indirect way. Intermediate results (not shown) indicate that 60% of the increase in petroleum and 35% of the increase in carabao services are due to increases in consumption resulting from increases in income.

The model contains the assumption that the purchase of agricultural machinery like power tillers, tractors, irrigation pumps and threshers are dependent on the savings behavior of household classes. Given the existing production, consumption and income distribution parameters, most investments in agricultural machinery are likely to occur in pump irrigated systems, followed by gravity and rainfed systems. Upland systems, because of their extremely low productivity, represent the least desired area of agricultural investment.

Income distribution within the rice economy

The results on income distribution within the rice economy obtained from the model are presented in Table 5. In the table, income inequality is measured by the ratio of landowner/hired labor and operator's gain in income.

The results indicate that using pump irrigation systems to produce the increased rice leads to the greatest increase in income for the rice economy closely followed by gravity and distantly followed by rainfed and upland systems. It is further observed that the increments to income in the rice economy fall off with increasing levels of mechanization. This probably occurs as the positive production effects are gradually offset by negative consumption effects resulting from lower propensity to consume of the main beneficiary of mechanical change, i.e. landowner. The model does not reflect how landowners might utilize this additional savings and it is likely that incorporation of their investment behavior would present a different picture about long term income generation capacities of the mechanized systems. Even with the present model, the increments to income from a mechanized system in a given water regime may be higher than from a non-mechanized system in other water regimes.

The various rice farm household groups are differently benefited from the four farm mechanization programs. The relative shares of hired labor households decline with moderate to high levels of mechanization while the share of farm operators and landowners increase so that overall income distribution worsens as indicated by our inequality measure. However, two points should be noted: a highly mechanized irrigation system (4) generates as much absolute income gain for hired labor as a non-mechanized rainfed system (9), and power tiller technology combined with hand threshing seems to improve the income distribution in some of the water regimes compared to using carabao.

Another observation is that while power tillers have high output and low redistributive effects threshers and tractors on the contrary have high redistributive and low output effects. Inequality increases with mechanization more in the rainfed than in the irrigated systems.

Income distribution among household classes

The results on income distribution among household classes appear in Table 6. We measure the rural-urban income disparity by the ratio of nonfarm to farm sector gain in income.

The different water regimes differ with respect to their income generating capacities. Pump irrigated systems yield the largest increase in national income, followed by gravity, rainfed and upland systems. Increasing mechanization usually results in declining income probably because of lower consumption effects among the direct beneficiary of mechanization.

The results indicate that mechanization in general leads to greater inequalities in rural-urban income distribution. This happens first because mechanization depends on industrial sectors for the supply of machinery and second because within the rice economy, income is redistributed in favor of household classes whose consumption patterns are biased towards luxuries produced in urban areas.

Increasing rice production in the rainfed and upland systems with or without mechanization results in the greatest increase in rural-urban income disparity, probably due to their dependence on land for the incremental output, with land's earnings, in turn, going to landowners.

Income, Consumption, Savings and Import

Mechanization leads to a simultaneous change in national and per capita income, consumption, savings, imports and labor's share with the results shown in Table 7. The largest increase in per capita income occurs with pump irrigation systems under low levels of mechanization, closely followed by gravity and distantly followed by rainfed and upland systems. Though for a given water regime, mechanization yields a lower level of per capita income, comparing across water regimes shows that per capita incomes under the mechanization alternative may be well over those attained under non-mechanized systems. The falling per capita incomes with rising mechanization is due to the low propensity to consume and high propensity to import of the main beneficiaries of the machines rather than low productivity as is the case with rainfed and upland systems.

Mechanization leads to increased savings because of an increase in profit as a proportion of value added. The rise in savings marks an increase in resources available for agricultural capital formation. However, the model does not describe how the additional savings are utilized for agricultural capital formation.

The volume of imports rise with levels of mechanization, but as incomes also increases, the ratio of import/income remains constant.

The systems in pump irrigation regimes generate the largest labor share compared to corresponding systems in other water regimes.

CONCLUSIONS

The study used 1978 national income and input-output data to derive employment, income distribution and resource utilization implications of rice farm mechanization. A number of important conclusions emerge from the study. Though the frailties of the data base and the nature of assumptions made in deriving results demand some caution in drawing conclusions, nevertheless, the consistence and orders of magnitude of the major findings reinforce our confidence in the results. The calculated employment increase for a one percent increase in consumer spending for rice varies from 23,000 workers using the fully mechanized option under rainfed conditions to 53,000 workers using the low level of mechanization in pump irrigated systems. The increase in employment that occurs seems to depend importantly on the consumption linkages that arise from a decrease in the personal income/savings ratio and to a shift of private consumption towards more labor-intensive products. The consumption connection is usually neglected in farm employment studies. The direct increase in employment is around 30-35% of total increase. The largest increment in employment takes place in non-rice activities. The direct effect alone overestimates the true displacement of labor by 5-10%.

The quantitative values of the quasi-elasticities can be used by policy makers in calculating total requirements of resources needed for carrying out a given program of rice production. One important result is that mechanization leads to a greater efficiency in resource allocation as indicated by the declining natures of quasi-elasticities with increasing levels of mechanization.

Alternative mechanization strategies benefit various rice farm households (hired labor, farm operator and landowners) in a different manner. Thus, while fully mechanized systems using four-wheel tractors and large axial flow threshers are sure to divert income from hired labor to landowner, power tiller technology used with hand threshing increases labor's share.

The income gap between rural and urban sectors is found to widen with increasing intensity of mechanization. The solution to this problem requires wide dissipation of industrial activities, especially the agricultural machinery sector and its related repair services into the rural and semi-urban areas.

Mechanization leads to an increase in the savings ratio, via an increase of profit in value added. The rise in savings marks an increase in total resources available for agricultural capital formation which may lead to higher future growth inspite of slight lower present income. However, the present static model cannot reflect such effects.

On the basis of the above results, we conclude that irrigation can contribute the maximum to development of the rice sector but that farm mechanization based on power tillers and small threshers is a sound economic measure with a minimum displacement of labor. The high technology systems using big tractors and large threshers posses a clear advantage over low and medium technology systems in generating surplus from the rice sector which would otherwise be a semi-subsistence one. With proper public policies, a part of the surplus should be diverted towards agricultural capital formation so that its reinvestment might open the possibility of higher rates of employment and income growth.

Several cautionary points must be raised. The data used to generate the rice production sub-sectors were based on small sample surveys. They do not, therefore, give the true national coefficients, although they were adjusted to be consistent with the national coefficients. An improved model would result from using national data for the technical coefficients of the subsectors. Also, we have assumed that all four levels of mechanization give the same yield and use the same level of fertilizer and chemicals with a given irrigation system. If this is not true on a national basis its correction would lead to different results.

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Table 1. Thirteen systems for rice production in the Philippines.

System	Power	Irrigation	Thresher
1	Carabao	Gravity	Hand
2	Power tiller	Gravity	Hand
3	Power tiller	Gravity	Small portable
4	Tractor	Gravity	Large axial flow
5	Carabao	4" pump	Hand
6	Power tiller	4" pump	Hand
7	Power tiller	4" pump	Small portable
8	Tractor	10" pump	Large axial flow
9	Carabao	Rainfed	Hand
10	Power tiller	Rainfed	Hand
11	Power tiller	Rainfed	Small portable
12	Tractor	Rainfed	Large axial flow
13	Carabao	Upland	Hand

Table . Descriptions of five agricultural machinery manufacture sectors.

Sub-sectors	Type of machinery	Descriptions	Horse power	Cost to farmers (US$)
1	Power tiller	2-wheel with steering clutches and attachments	6-8	1,735
2	Tractor	4-wheel	35	16,000
3	Irrigation pump	4"Ø axial flow propeller	5	840
4	Portable thresher	TH6-IRRI design without oscillating screen	7	1,040
5	Large axial flow thresher	TH8-IRRI design with cleaner	12	2,265

Table 3. Employment implications of a 1 percent increase in consumer spending for rice when demand is met from specified rice production sector.

Sector number	Rice Production Sectors: Power	Irrigation	Thresher		Total employment (thousands) (1)	Absolute increase (thousands) (2)	Direct increase (thousands) (3)	Indirect increase (thousands) (4)	Ratio of indirect/direct employment effect (5)
				Actual Economy, 1978	16,968				
1	Carabao	Gravity	Hand		17,010	42	14.5	27.5	1.89
2	Power tiller	Gravity	Hand		17,011	43	15.9	27.1	1.70
3	Power tiller	Gravity	Small portable		17,008	40	12.4	27.6	2.23
4	Tractor	Gravity	Large axial flow		17,004	36	11.2	24.8	2.21
5	Carabao	4" pump	Hand		17,023	55	23.7	31.3	1.32
6	Power tiller	4" pump	Hand		17,021	53	21.7	31.3	1.44
7	Power tiller	4" pump	Small portable		17,017	49	17.4	31.6	1.82
8	Tractor	10" pump	Large axial flow		17,005	37	9.0	28.0	3.11
9	Carabao	Rainfed	Hand		16,999	31	11.0	20.0	1.81
10	Power tiller	Rainfed	Hand		16,996	28	9.7	18.3	1.89
11	Power tiller	Rainfed	Small portable		16,995	27	7.3	19.7	2.70
12	Tractor	Rainfed	Large axial flow		16,991	23	5.3	17.7	3.34
13	Carabao	Upland	Hand		16,986	18	5.1	12.9	2.53

Table 4. Quasi-elasticities showing the direct and indirect resource requirements of a one percent increase in rice production from specified rice production sector.

Sector number	Rice Production Sectors: Power	Irrigation	Thresher	Fertilizer	Chemical products	Petroleum products	Carabao and other agricultural service	Power tiller	Tractor	Irrigation pump	Small portable thresher	Large axial flow thresher
			Actual Economy, 1978 Total (ml. ₱)	1395.4	9539.6	11240.1	10606.8	134.1	154.9	22.0	18.2	35.6
1	Carabao	Gravity	Hand	0.564	0.246	0.164	0.231	0.221	0.292	0.265	0.226	0.206
2	Power tiller	Gravity	Hand	0.561	0.248	0.166	0.215	0.400	0.293	0.266	0.226	0.206
3	Power tiller	Gravity	Small Portable	0.557	0.245	0.164	0.209	0.410	0.302	0.275	0.553	0.215
4	Tractor	Gravity	Large Axial flow	0.549	0.228	0.152	0.205	0.207	0.715	0.247	[illegible]	[illegible]
5	Carabao	4" Pump	Hand	0.487	0.286	0.199	0.270	0.251	0.335	2.17	0.257	[illegible]
6	Power tiller	4" Pump	Hand	0.478	0.234	0.193	0.250	0.418	0.337	2.16	0.259	[illegible]
7	Power tiller	4" Pump	Small Portable	0.473	0.278	0.193	0.241	0.436	0.343	2.19	1.336	[illegible]
8	Tractor	10" Pump	Large Axial flow	0.499	0.278	0.172	0.205	0.229	0.532	3.77	0.234	0.713
9	Carabao	Rainfed	Hand	0.384	0.176	0.122	0.186	0.139	0.192	0.172	0.143	0.134
10	Power tiller	Rainfed	Hand	0.371	0.169	0.118	0.148	0.362	0.198	0.179	0.132	[illegible]
11	Power tiller	Rainfed	Small Portable	0.376	0.177	0.123	0.154	0.375	0.216	0.199	0.562	0.133
12	Tractor	Rainfed	Large Axial flow	0.365	0.161	0.111	0.151	0.145	0.705	0.174	0.149	[illegible]
13	Carabao	Upland	Hand	0.153	0.114	0.084	0.133	0.094	0.129	0.116	0.097	[illegible]

Table 5. Income redistribution implications for rice farm households of a 1 percent increase in consumer spending for rice when demand is met from specified rice production sector.

Sector number	Rice Production Sectors: Power	Irrigation	Thresher	Hired labor: Absolute increase (million peso)	Hired labor: Incremental share	Operator: Absolute increase (million peso)	Operator: Incremental share	Landowner: Absolute increase (million peso)	Landowner: Incremental share	Ratio of landowner/hired labor and operator incremental income	Total incremental income of rice farm
			Actual Economy 1978 Income (ml. ₱)	2594.0	-	3469	-	2503.0	-	-	5366
1	Carabao	Gravity	Hand	34.3	(28.3)	49.9	(41.2)	36.8	(30.5)	0.438	121.0
2	Power tiller	Gravity	Hand	37.1	(29.9)	51.1	(41.0)	36.3	(29.1)	0.410	124.5
3	Power tiller	Gravity	Small Portable	30.3	(24.8)	51.5	(42.0)	40.5	(33.2)	0.497	122.3
4	Tractor	Gravity	Large Axial flow	27.0	(25.3)	44.6	(41.8)	35.0	(32.9)	0.490	106.6
5	Carabao	4" Pump	Hand	51.1	(33.5)	60.0	(39.3)	41.1	(27.2)	0.374	152.2
6	Power tiller	4" Pump	Hand	47.7	(31.2)	63.8	(41.7)	41.3	(27.1)	0.372	152.8
7	Power tiller	4" Pump	Small Portable	39.6	(26.8)	61.5	(41.6)	46.6	(31.6)	0.462	147.7
8	Tractor	10" Pump	Large Axial flow	23.6	(21.0)	47.8	(42.3)	41.5	(36.7)	0.530	112.9
9	Carabao	Rainfed	Hand	27.4	(36.3)	29.3	(38.8)	18.8	(24.9)	0.332	75.5
10	Power tiller	Rainfed	Hand	24.2	(32.1)	27.8	(36.9)	23.3	(31.0)	0.449	75.3
11	Power tiller	Rainfed	Small Portable	19.5	(24.1)	34.2	(42.2)	27.1	(33.7)	0.506	80.8
12	Tractor	Rainfed	Large Axial flow	15.1	(22.5)	28.6	(42.5)	23.5	(35.0)	0.538	67.2
13	Carabao	Upland	Hand	14.0	(31.5)	17.3	(39.0)	13.1	(29.5)	0.418	44.4

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Table 5. Income redistribution implications for household classes of a one percent increase in consumer spending for rice when demand is met from specified rice production sector.

Sector Number	Rice Production Sectors: Power	Irrigation	Thresher	Actual economy, 1978 income (million ₱)	Rice Farm 8,566: Absolute increase (million ₱)	Incremental share	Non-Rice Farm 39,808: Absolute increase (million ₱)	Incremental share	Non-Farm 122,416: Absolute increase (million ₱)	Incremental share	Ratio of non-farm to farm incremental income	Total incremental income (million ₱)
1	Carabao	Gravity	Hand		121.0	(28.0)	95.3	(22.2)	215.3	(49.8)	0.995	431.6
2	Power tiller	Gravity	Hand		124.5	(28.4)	94.9	(21.6)	218.5	(50.0)	0.996	437.9
3	Power tiller	Gravity	Small Portable		122.3	(28.5)	91.6	(21.4)	214.3	(50.1)	1.001	428.2
4	Tractor	Gravity	Large Axial flow		106.6	(27.6)	83.8	(21.7)	195.5	(50.7)	1.026	385.9
5	Carabao	4" Pump	Hand		152.2	(28.7)	118.3	(22.3)	260.2	(49.0)	0.961	530.7
6	Power tiller	4" Pump	Hand		152.8	(29.0)	115.1	(21.8)	259.1	(49.2)	0.967	527.0
7	Power tiller	4" Pump	Small Portable		147.7	(29.0)	109.5	(21.6)	250.5	(49.4)	0.974	507.7
8	Tractor	10" Pump	Large Axial flow		112.9	(27.1)	87.8	(21.1)	215.8	(51.8)	1.075	416.5
9	Carabao	Rainfed	Hand		75.5	(26.0)	66.5	(22.9)	148.7	(51.1)	1.047	290.7
10	Power tiller	Rainfed	Hand		75.3	(27.0)	60.1	(21.5)	143.8	(51.5)	1.062	279.2
11	Power tiller	Rainfed	Small Portable		80.8	(27.4)	62.6	(21.2)	151.2	(51.4)	1.054	294.6
12	Tractor	Rainfed	Large Axial flow		67.2	(26.0)	55.8	(21.6)	135.1	(52.4)	1.098	258.1
13	Carabao	Upland	Hand		44.4	(24.0)	42.3	(22.9)	98.4	(53.1)	1.134	185.1

Table 7. Income, consumption, savings, imports and compensation for employees implications of a one percent increase in consumer spending for rice when demand is met from specified rice production sector.

Sector Number	Rice Production Sectors: Power	Irrigation	Thresher	Per Capita income (₱)	National income	Ratio of personal consumption expenditure/ national income	Ratio of savings and taxes/national income	Ratio of imports/ national income	Ratio of compensation for employees/ national income
			Actual economy 1978	3,754 (₱) (1)	170,790 (mil₱) (2)	0.67187 (3)	0.32813 (4)	0.24366 (5)	0.37078 (6)
1	Carabao	Gravity	Hand	3,763.9	171,221	0.67202	0.32798	0.24362	0.37076
2	Power tiller	Gravity	Hand	3,764.0	171,228	0.67202	0.32798	0.24362	0.37078
3	Power tiller	Gravity	Small Portable	3,763.8	171,218	0.67201	0.32799	0.24362	0.37072
4	Tractor	Gravity	Large Axial flow	3,762.9	171,176	0.67200	0.32800	0.24364	0.37074
5	Carabao	4" Pump	Hand	3,766.1	171,320	0.67206	0.32794	0.24360	0.37083
6	Power tiller	4" Pump	Hand	3,766.0	171,317	0.67206	0.32794	0.24360	0.37080
7	Power tiller	4" Pump	Small Portable	3,765.5	171,297	0.67204	0.32796	0.24361	0.37074
8	Tractor	10" Pump	Large Axial flow	3,763.5	171,206	0.67199	0.32801	0.24368	0.37068
9	Carabao	Rainfed	Hand	3,760.8	171,080	0.67197	0.32803	0.24363	0.37082
10	Power tiller	Rainfed	Hand	3,760.5	171,069	0.67196	0.32804	0.24363	0.37079
11	Power tiller	Rainfed	Small Portable	3,760.9	171,085	0.67197	0.32803	0.24363	0.37073
12	Tractor	Rainfed	Large Axial flow	3,760.1	171,048	0.67195	0.32805	0.24365	0.37073
13	Carabao	Upland	Hand	3,758.5	170,975	0.67193	0.32807	0.24363	0.37078

Appendix A. Calculation of cost and returns in 13 systems of rice production, 1978.*

No.	Rice Production System: Power	Irrigation	Thresher	Location	Intermediate cost[d] (peso/hectare/season): Seed	Carabao	Fertilizer	Chemicals	Fuel or lubricants	Agricultural machinery	Factor earnings[d] (peso/hectare/season): Hired labor	Operator	Landowner	Taxes (₱)	Total value[d] (₱)	Yield kg	Cropping intensity %	Proportion of rice produced
1[a]	Carabao	Gravity	Hand	Central Luzon	75	200	194	40	0	0	657	964	722	88	2940	3000	133	20%
2[a]	Power tiller	Gravity	Hand	Central Luzon	75	0	194	40	73	36	719	988	707	88	2940	3000	133	5%
3[a]	Power tiller	Gravity	Small portable	Central Luzon	75	0	194	40	85	82	564	1003	809	88	2940	3000	133	6%
4[a]	Tractor	Gravity	Large axial flow	Central Luzon	75	106	194	40	94	195	518	890	720	88	2940	3000	133	11%
5[a]	Carabao	4" pump	Hand	Laguna	50	198	129	111	335	100	1025	1160	795	117	3920	4000	200	3%
6[a]	Power tiller	4" pump	Hand	Laguna	50	0	129	111	405	156	946	1253	803	117	3920	4000	200	1%
7[a]	Power tiller	4" pump	Small portable	Laguna	50	0	129	111	418	190	764	1209	932	117	3920	4000	200	3%
8[a]	Tractor	10" pump	Large axial flow	Mindanao	75	0	356	226	617	300	413	931	875	117	3920	4000	200	1%
9[b]	Carabao	Rainfed	Hand	Iloilo	66	296	114	10	0	0	541	535	340	58	1960	2000	105	38%
10[b]	Power tiller	Rainfed	Hand	Iloilo	66	0	114	10	73	61	475	645	458	58	1960	2000	105	2%
11[b]	Power tiller	Rainfed	Small portable	Iloilo	66	0	114	10	85	78	356	664	541	58	1960	2000	105	2%
12[b]	Tractor	Rainfed	Large axial flow	Iloilo	66	126	114	10	102	198	267	550	469	58	1960	2000	105	2%
13[c]	Carabao	Upland	Hand	Average	71	~~260~~	13	8	0	0	[a]265	320	246	37	1225	1250	85	6%

Source: a Quantity data from Herdt and Lacsina 1976.
b Quantity data from Herdt and Gonzales 1980.
c Quantity data from Dozina and Herdt 1974.
d Price data from BAEcon.

*See text for methodology.

CONSEQUENCES OF SMALL RICE FARM MECHANIZATION PROJECT

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