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MEASURING CONSUMPTION LINKAGES OF MECHANICAL TECHNOLOGIES IN PHILIPPINE RICE PRODUCTION

by

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MEASURING CONSUMPTION LINKAGES OF MECHANICAL TECHNOLOGIES IN PHILIPPINE RICE PRODUCTION*

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Abstract

A variant on the Social Accounting Matrix method is used to measure consumption linkages of alternative rice production technologies. The model is built for technology observed in the Philippines. Consumption linkages are computed by incorporating 'consumption,' 'distribution,' and 'import substitution' effects. One essence of the input-output framework is the recognition of multiple sub-sectors for production of a single product (rice). Simulations consider a one percent change in consumer spending for rice met from one sub-sector compared to another. Results indicate that the changes in employment that occur under different technological options depend importantly on the indirect effects arising from consumption linkages.

INTRODUCTION

The importance of consumption linkages in the agricultural growth process has been emphasized by a number of scholars (Johnston and Kilby 1975, Mellor 1976). Differences in the consumption patterns of different socio-economic classes affect the rate, pattern and time sequence of changes in demand, which in turn affect the markets for different products in different ways. Changes in production of products to meet those demands require different ratios of capital and labor, depending on the factor intensities of the technologies used. Adoption of modern technologies for rice production in Asia has been identified as a potential source of labor displacement (ILO 1980, UNRIDS 1976). However, the indirect effects of new technologies are generally ignored in such discussions, because they require a comprehensive analytical framework. In this paper we measure the

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consumption linkages and employment generation impacts of increasing rice production by alternative technologies, and apply the technique to data for the Philippines.

Most studies examining the employment impact of "green revolution" technologies focus on the use of labor in the production side of agriculture and ignore any demand or consumption influences (Duff 1978, Barker and Cordova 1979). The flaw in this partial approach is that changes in employment caused by technological change depend not only on the direct effect of employment in the primary production activity (rice), but on the indirect effects as well as on the changes in the pattern of demand caused by different consumption patterns of various socio-economic groups. The interlinked changes between a technology and its income generating impact and redistributive effects are of critical importance in determining the total employment impact of a given technology. Because of its sheer size, the rice sector offers particular opportunity for a net increase in employment through changes in consumption expenditures arising from substitution among alternative production technologies.

The indirect effects of new technologies stem from production and consumption interactions of the agricultural sector with the non-agricultural sectors. The production effects arise as adoption of technological innovations generates demand for agricultural machinery whose production in turn generates demand for engines, steel, bearings and manufacturing labor. The magnitude of the labor demand effect demands on the labor intensity of rice production (direct), farm machinery (indirect, first round), machinery that produces farm machinery (indirect, second round), and so on, ad infinitum. Consumption linkages arise from extra income earned by certain classes as a result of technological innovations which change the level of final demand. The magnitude and incidence of the consumption effects depends on the consumption pattern of household classes and the income distribution pattern of household classes.[1] Technological innovations are likely to change value added in gross output, and depending on how the additional value added is distributed to wages and profit, laborers or entrepreneurs are better off. The final factor affecting indirect effects is the import substitution[2] pattern in production and consumption. Production using less imported inputs increases domestic employment as does a consumption pattern weighted toward labor intensive goods. It is the net effect of all of the above mentioned factors that translate the change in degree of technological adoption to a change in employment and income distribution.

In this paper we use a variant of earlier Social Accounting Matrix (SAM) approaches. Krishna (1975) measured direct and indirect employment effects of growth and technical change in the farm sector using a conventinal input-output model. Paukert et. al. (1975) used a SAM methodology developed by Pyatt and Round (1977 and 1979) to present empirical results of the links between changes in income distribution

and changes in employment. Bell and Hazell (1980) measured indirect effects of an agricultural investment project on its surrounding region. Weisskoff's model (1971) calculated employment effects for alternative sequence of import substitution and export promotion strategies. Thorbecke et. al. (1972) checked the feasibility of full employment using an input-output framework. We extend these earlier approaches by identifying and measuring the effects of a series of different technologies for rice production.

METHODOLOGICAL CONSIDERATIONS

The basis for our analysis is the national input-output matrix for the Philippines. In order to reflect alternative technological strategies for rice production and to capture their direct and indirect effects the rice sector in that matrix is separated into 13 subsectors, differing by level of farm mechanization and associated water-topographical regimes (Table 1). Similarly, the agricultural machinery sector is separated into 5 sub-sectors corresponding to 5 specified rice production machine groups (Table 2). Five groups of consumers, with different consumption parameters and different resource ownership patterns are defined.

Specifying which system produces what amount of final demand, the model uses semiclosed input-output relations to compute domestic production and intermediate imports required to meet the demand. The factor shares of production then determine income distribution among owners of factors which in turn affects the volume and pattern of private consumption and savings. Finally, the model computes the corresponding employment and personal income of each consumption group. Comparison of the results obtained with varying proportions of total rice output produced by the 13 sectors provides a measurement of the effect of moving toward different patterns of technological innovation.

The National Economic and Development Authority's 63-sector input-output model of the Philippines (1978b) was consolidated into a 30 x 30 sector model. The disaggregation of the rice and agricultural machinery sectors were added to that 30 x 30 matrix to give an input-output table of 46 x 46 sectors. The augmented matrix (46 x 46) met two criteria: the individual technological coefficients in the rice and farm machinery sub-sectors had to be consistent with known differences and had to aggregate into national technological coefficients (for rice or farm machinery) equal to the sectoral coefficient that appears in the original input-output table.

We distinguish five household classes to incorporate the income distribution, consumption, saving and import substitution effects of technological innovations. For rice farm households, our definitions

rest on endowments of land, labor and capital; the other household classes are defined as non-rice farm households and non-farm households.

The first class, hired labor households, derive their income from labor services in rice farming. Landowner households include farmers as well as landlords. Their incomes consist of the returns from land and capital. Farm operator households are defined as renters of land, and 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 Model

Five groups of equations comprise the model: production and household consumption, import, saving, income and employment.

The first set achieves material balances among all production sectors and household classes. The equations are built around fixed input-output and household expenditure coefficients. Distribution of consumption expenditures (for domestic items) by household classes result from the assumptions of a consumption function in which the expenditure share of a given commodity in the total (pre-tax) income of the household remains constant.

Imports are disaggregated in two groups: imports for intermediate use and imports for consumption. Both groups of imported goods are fixed in proportion to sectoral outputs and household incomes respectively.

Saving is defined as a residual obtained by subtracting consumption expenditure on domestic and imported items from (pre-tax) gross income. It therefore follows that total expenditure on private consumption (domestic and imported items) plus private savings in each household class is equal to total income of the class.

Gross value added in each of the rice systems is allocated as payments to operators, laborers and landlords. These payments determine income for the first, second and third groups of household classes. Non-rice farm income and non-farm income are assumed to be fixed proportions of total output in these sectors. Income components generated for each of the household classes per unit of sectoral output produced are assumed to remain constant.

Employment in each sector is assumed to be determined by fixed sectoral labour-output ratio. Total employment is obtained by summing employment of all sectors.

In its most general formulation the variant of the SAM model discussed above can be written as

(1) $Q.R = Z$

where Q is a 54 x 54 square matrix of structural coefficients,
R is a 54 x 1 column vector of the endogenous variables,
Z is a 54 x 1 column vector of the exogenous variables.

The solution is obtained as

(2) $R = Q^{-1}.\ Z$

The components of the Q.R and Z matrices are:

$$(3)\quad \left[\begin{array}{c|c|c|c} I-A & 0 & -C_c & 0 \\ \hline -A_m & I & -C_m & 0 \\ 0 & & -C_s & \\ \hline -A_k & 0 & I & 0 \\ \hline -A_L & 0 & 0 & I \end{array}\right] \left[\begin{array}{c} X \\ \hline M \\ S \\ \hline Y \\ \hline L \end{array}\right] = \left[\begin{array}{c} F \\ \hline 0 \\ \hline 0 \\ \hline 0 \end{array}\right]$$

$$Q \qquad R \qquad Z$$

where X is a 46 x 1 vector of outputs, x_j

A is 46 x 46 square matrix of technological coefficients.

With elements a_{ij}'s defined as

(4) $a_{ij} = x_{ij}/x_j$, i, j = 1, 2 ----46.

x_{ij} is the intermediate delivery of sector i to sector j.

Y is the 5 x 1 vector of household class incomes, y_k's

C_c is a 46 x 5 rectangular matrix of domestic consumption coefficients with elements c_{ik}'s defined as

(5) $c_{ik} = e_{ik}/y_k$ (i=1, 2....46, k = 1,2.....5)

where e_{ik} is the expenditure on private consumption of domestic commodity i by household class k.

F is a 46 x 1 vector of exogenous final uses, e.g. government consumption, stocks, exports and imports.

A_m is a 1 x 46 vector of intermediate import coefficients with elements a_{mj}'s defined as

(6) $a_{mj} = m_j/x_j$

where m_j is intermediate imports by sector j.

C_{am} is a 1 x 5 vector of private consumption of imported goods defined as

(7) $m_{ck} = e_{mk}/y_k$

where e_{mk} is private consumption of direct imports in the kth household class.

C_{as} is a 1 x 5 vector of private savings with elements c_{sk}'s defined

(8) $c_{sk} = \frac{s_k}{y_k}$

where s_k is private savings for the kth household class defined as a residual

(9) $s_k = y_k - \sum_{i=1}^{46} c_{ik} - c_{mk}$

A_k is a 5 x 46 rectangular matrix of income coefficients with elements a_{kj}'s defined as

(10) $a_{kj} = \frac{y_k}{x_j}$

M is total imports

S is total savings

L is total labor employment

A_l is a 1 x 46 vector of labor coefficients with elements a_{ij}'s defined as

(11) $a_{lj} = l_j/X_j$

where l_j is employment in jth sector.

The elements of the main diagonal of matrix Q are positive. The 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 will have an inverse.

The Modified Model

The SAM model discussed above is based on the assumptions of perfectly elastic supplies in all sectors. This assumes that each sector faces constant average costs as well as perfectly elastic supplies of all inputs and resources. This may be realistic for imports, and small scale manufacturing and service activities, but it may not be a reasonable assumption for primary activities and capital intensive manufacturing and infrastructure services. These sectors cannot easily respond to increased demand in the short run, and much of the increased demand is likely to be translated into price increases, at least until sufficient investment has been made to increase output. One feature of the Bell-Hazell (1980) study was a modification of input-output methods to enable a choice of fixing either the output or the exports level for each sector. Following their method one can choose to assume for each sector whether supplies are perfectly elastic or perfectly inelastic. The latter assumption may be more relevant for primary activities and capital intensive non-farm activities, whereas the perfectly elastic assumption may be retained for other sectors.

Let the primary activities and capital intensive non-farm sectors be denoted by subscript P (Agricultural crops, forestry and fishery, carabao services, mining and quarrying, sugar milling and refining, textiles and footwear, paper products and printing, cement, basic metal and metal products, electricity and gas manufacture) and rest of the sectors by subscript V.[3] The following rearrangement of our original model (Eqn. 3) can be made.

To measure employment generated by the consumption and production linkages of the modern technologies in rice we proceed in two steps. First, we simulate the complete model as expressed in Equations 3 and 11 with a 1% exogenous increase in consumer demand for rice fully met from a given sub-sector. The matrix is then inverted and finally post-multiplied by the constant vector (matrix) of exogenous variables in order to obtain the solution vector. This gives 13 simulations for 13 sub-sectors; in each the c_{ik} parameters for the relevant rice sub-sector i are increased to accommodate the shift in consumption expenditure for rice. Second, we consider a subset of the

$$
(11)\quad
\begin{bmatrix}
I-A_{vv} & 0 & 0 & -C_{cv} & 0 \\
-A_{pv} & -I & 0 & -C_{cp} & 0 \\
\begin{matrix}-A_{mv} \\ 0\end{matrix} & 0 & I & \begin{matrix}-C_{m} \\ -C_{s}\end{matrix} & 0 \\
-A_{kv} & 0 & 0 & I & 0 \\
-A_{lv} & 0 & 0 & 0 & I
\end{bmatrix}
\begin{bmatrix}
X_v \\ F_p \\ \begin{matrix}M \\ S\end{matrix} \\ Y \\ L
\end{bmatrix}
$$

$$
\begin{bmatrix}
I & A_{vp} & 0 & 0 & 0 \\
0 & -I+A_{pp} & 0 & 0 & 0 \\
0 & \begin{matrix}A_{mp} \\ 0\end{matrix} & 0 & 0 & 0 \\
0 & A_{kp} & 0 & 0 & 0 \\
0 & A_{lp} & 0 & 0 & 0
\end{bmatrix}
\begin{bmatrix}
F_v \\ X_p \\ 0 \\ 0 \\ 0
\end{bmatrix}
$$

Equations 3 and 11 are utilized to obtain our empirical results.

model relationships containing equations for production and employment[4] and simulate the effect of a 1% exogenous increase in consumer demand for rice fully met from a given sub-sector. We again have 13 simulations; in each the household consumption components in vector F are increased to reflect the shift in consumption for the relevant rice sub-sector. Comparison of employment in two simulations allows total effects to be decomposed into production and consumption impacts.

The study is a static comparative simulation exercise, measuring employment generated by consumption and production linkages under alternative assumptions about water control, topography and degrees of mechanization. We use a system of exclusively linear homogenous equations which allows us to obtain solutions by simple matrix inversion operations.

The most important limitations of the model are assumptions of fixed coefficient production function, unitary elasticities of demand, constant returns to scale, free labor force resources and no capacity limitations, and no balance of payment limitations.

DESCRIPTION OF DATA

Three alternative techniques of land preparation are specified in the rice production systems: carabao (water buffalo), power tiller, and tractor. Three threshing techniques are included: manual, portable and large axial flow thresher. These are combined to form 4 successively higher levels of mechanization within three water regimes. The first is non-mechanized, the fourth is fully mechanized, while the second and third are intermediate. One additional non-mechanized dry land system is included. Input-output data on the four systems were based on data obtained from a number of farm level studies (Dozina and Herdt 1974, Herdt and Lacsina 1976).

The following cropping intensity indices are assumed: 133% on gravity irrigated carabao operated farms, 146% on gravity irrigated farms using power tillers or tractors, 200% for pump irrigated carabao and 220% for pump irrigated farms using power tillers or tractors; 105% on rainfed farms regardless of power source, and 85% on upland farms.

A budget was developed for each of the rice production systems, showing the breakdown of costs and the earnings accruing to hired labor, farm operator, and landowner. Total value of output was allocated to intermediate inputs, labor earnings, return to land, taxes and operator's residual. Intermediate inputs were separated into seed, carabao, fertilizer, other chemicals, fuel and lubricants and machinery.

Cost of agricultural machinery use was separated into (i) depreciation, (ii) returns to capital, (iii) fuel and lubricants, (iv) repair and (v) labor costs. Repair costs is assumed to consist of half labor cost with other half distributed as depreciation and returns to capital in the same proportion as the original machine.

The returns to land, labor and capital are apportioned to household classes in the following manner. Landowners' income equals rent on land, 50 percent of capital consumption and family labor allowances. Capital consumption allowance includes returns to capital for both the machinery and the spare parts plus interest charges. 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 tariff rates on agricultural inputs and machinery were obtained from tariff and customs code of the Philippines.

A budget showing intermediate and primary costs involved in the construction of each of the 5 agricultural machines was developed based on data obtained from the industrial extension unit of the IRRI Engineering Department. Small scale machines like power tillers, threshers, and irrigation pumps are domestically manufactured with imported engines, while wheel tractors are imported on either a partly knockdown or a completely knockdown basis.

The data on consumption patterns of households were obtained from the 1975 Family Income and Expenditure Survey of the National Census and Statistics Office (NCSO). The five household classes in the model are assumed to correspond to five income classes in the survey: landowners to income ranging ₱8,000-10,000 (the highest 10% of rural households), operators to have income ranging ₱3,000-4,000 (the median group of rural households), hired labor to have income ranging from ₱1,000-1,500 (the lowest 10% of rural households), non-rice farm households to have income ranging from ₱4,000-5,000 (average rural households) and non-farm households to have income ranging ₱6,000-8,000 (average income of urban households). The model requires us to distinguish consumption expenditure on each item by household classes. For this purpose, consumption items were aggregated from the original 45 categories of the 1975 Family Income and Expenditure survey into a 30 category breakdown to correspond to the 1978 Input-Output table.

Import data are taken 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 data on import propensities of consumption for different household classes are estimated from 1975 Family Income and Expenditure Survey.

Savings and taxes include personal plus corporate savings and direct plus indirect taxes. Data on aggregate savings and taxes are obtained from National Income Accounts (1978). The aggregate savings and tax figures are disaggregated into separate household classes using the 1975 Family Income and Expenditure survey.

Data on the labor force are taken from the survey of households bulletin (1978) of the National Census and Statistics Office. The data include both unemployed and employed labor force.

MODEL SIMULATIONS AND RESULTS

Model simulations consider a one percent increase in consumer spending for rice fully met from a given sub-sector. One percent of total consumer spending on rice equaled P99.3 million with a purchase capacity of 45.2 thousand tons of milled rice or 76.5 thousand tons of rough rice. In the tables showing the results, the rice production technologies are arranged in ascending order of mechanization so that a comparison within a given water regime yields the production and consumption effects of mechanization. Comparison across water regimes reflects the production and consumption effects of irrigation.

Consumption and Production Effects of Employment: Mechanization

Employment in the rice sector consists of both family and hired labor. However, as non-rice employment is calculated from labor coefficients in the national input-output table it refers to hired labor only. The production effect is separated into two components: direct effects that refer to employment in the rice sector arising from production and consumption linkages for rice, and indirect effects that show labor employment in non-rice sectors by 'backward' and 'forward' production linkages. Consumption effects are 'indirect' by nature and signify change in employment that can be supported in the non-rice sectors from the income flow of a given level of technology taking into account possibilities of import substitution in consumption. Both production and consumption effects, whether direct or indirect are measured as equilibrium values.

Consumption and production effects of employment that arise from mechanization under various water regimes are shown in Table 3. The results (first row) indicate that if the increased rice demand is met by increasing production from an irrigated sub-sector using a power tiller rather than a carabao, employment would increase, while a similar change in land preparation power source under rainfed conditions would lower employment. The increase in employment seems to depend importantly on the consumption linkages, which are much higher

in the irrigated regimes because of increased use of hired labor in land preparation. If the consumption linkages were ignored, as happens in partial analysis, the net effect on employment would appear to be negative; and this would be true even in irrigated regimes. This dramatizes the need for inclusion of consumption linkages in evaluating potential new technologies.

The second row in Table 4 shows the production and consumption effects of adopting small threshers. In constrast to the previous case, here both the direct effect and that portion of the indirect effect traceable to consumption effects is negative and offsets any increase in employment due to the indirect production effect. This is because threshers lead to a decline in hired labor and because the landless have higher consumption propensities than other classes. However, looking across columns shows that the decline in employment associated with thresher use diminishes with increasing level of irrigation. This happens as the decline in consumption effects become smaller while at the same time the increase in production effect becomes greater in more intensive irrigated regimes. Irrigated regimes with more income and a better distribution have far more consumption linkages than rainfed systems.

The third row shows the production and consumption linkages of employment effects in different water regimes from a one percent increase in consumption met by increasing production from the large tractor and large thresher sub-sector instead of the power tiller and small thresher sub-sector. It appears that the decline in net employment from this transformation is lower than that occuring from a substitution of manual for mechanical thresher as indicated in the second row. However, this result is achieved by a greater decline in the consumption effect and a smaller decline in the production effect which may have important bearing on welfare considerations. The decline in direct employment is also lower than the previous case implying that employment in the rice sector remains relatively high.

The implication of the results in Table 3 are that in most cases micro-studies using farm employment data overestimate the net displacement of labor associated with mechanization. However, the indirect consumption effects may either reinforce the direct labor displacement effect or offset it, depending on the consumption patterns of the household classes who receive increased income.

The value in parenthesis in table 3 refer to results obtained from the modified version of the model characterized by fixity of supplies for the primary and capital intensive non-farm sectors. Quite obviously, the magnitudes (in absolute values) of production and consumption effects (both direct and indirect) are smaller than those in the original model. This happens due to truncation of the multiplier process for sectors marked by fixed supply. Comparing

across rows shows that the decline (in absolute values) in total effect is more severe for intensive irrigated systems for a given mechanization level. This reflects the fact that irrigated regimes which have more production and consumption linkages are affected more by the truncation of the multiplier process.

Consumption and Production Effects of Employment: Irrigation

In Table 4, we separate the consumption from the production effects on employment for different levels of irrigation. Unlike in the case of mechanization (Table 3), here direct employment increases as one moves from upland to rainfed to irrigated rice. This happens because the direct impact on hired labor employment brought about by intensive irrigated systems is much larger than the reduction in family labor that also occurs (Barker and Cordova 1978; Smith and Gascon 1979) and because landless have higher consumption propensities than farmers. Thus, if carabao techniques meet the one percent increase in rice demand from rainfed lowland instead of from upland total employment increases by 11.8 thousand. Consumption linkages account for over 57% of that increase in employment (6.74 thousand man-years), while direct and indirect production effect constitute 40% and 1% (4.9 and 0.16 thousand man-years) respectively.

The second row measures consumption and production effects of employment from producing the increases output in gravity irrigated rather than rainfed systems. The increase in total employment with carabao is 13.97 thousand man-years, with power tiller 15.42 thousand man-years, with power tiller and small thresher 16.54 thousand man-years and with tractor and large thresher 19.01 thousand man-years. Consumption effects constitute a major portion of total employment effect (77 to 79 percent), while the indirect production effect is relatively smaller (1 percent).

The third row shows consumption and production effects of employment for a change from gravity to 4" pump under various levels of mechanization. Here also the consumption effect constitutes a major portion of the total employment effect though they are smaller (50 to 53 percent) than the previous case (row 2). Comparing three types of change: upland to rainfed, rainfed to gravity, and gravity to 4" pump, shows that a transformation from rainfed to gravity has much greater employment generating effects. In contrast to increasing mechanization, increasing the degree of water control gives consumption effects that are always positive and reinforce the production effect. If one compares across various columns (4, 8, 12 and 16) it is evident that the higher the level of mechanization, the larger the gain from an improvement in irrigation. Thus low productivity due to lack of water control and inadequate inputs rather than mechanization per se is responsible for low employment. It is also observed that production and consumption effects increase with increasing levels of mechanization for a given irrigation regime indicating that both

production and consumption linkages play a greater role under mechanization.

In Table 4, the values in the parenthesis refer to results obtained from the modified version of the model characterized by fixity of supplies for the primary and capital intensive non-farm sectors. As in the case of mechanization (Table 3), the magnitude (in absolute value) of production and consumption effects (both direct and indirect) are smaller than those in the original model. Consumption linkages, being more dominant for changes in water regimes, decline much more than production linkages. Comparing the second with the third row, one observes that total effect decline (in absolute value) more for a transformation from rainfed to gravity than from gravity to 4" pump with similar levels of mechanization. This reflects the fact that a change from rainfed to gravity that has more consumption and production linkages is affected more by truncation of multiplier process.

Table 5 shows sector-wise incremental production pattern for selected set of simulations. Thus if the increased rice demand is met by increasing production from the gravity sub-sector rather than rainfed sub-sector using carabao gross output rises by P748 million. Both consumption and production linkages account for the incremental production. The following sectors show sharp increase in production: Rice by 13 percent, other agricultural crops, livestock, forestry and fishery by 11 percent processed food by 15 percent manufacturing sector by 18 percent construction and services by 17 percent of total incremental production. The above pattern indicates that among other things, demand for food is likely to increase with modernization, even though the proportion of incremental income spent on food may decline as income increases. Inputs used in rice production (like carabao services, fertilizer and agricultural machinery) also show some increases in production but they are relatively smaller compared to sectors producing consumer goods needed by rice farm households.

CONCLUSIONS

This paper has used a variant of the social accounting matrix approach for measuring consumption and production linkages or employment under alternative rice production technologies as observed in the Philippines. The 1978 Philippine national income and input-output data provided a base for constructing the model, which incorporated 13 rice production sub-sectors. A number of important conclusions emerge from the study. Though frailties of the data base and the nature of some assumptions demand caution in drawing conclusions, nevertheless, the consistency and orders of magnitude of the major findings reinforce our confidence in the results.

The total employment effect of a given technology is separated into direct, indirect production and consumption effects. The direct effect refers to employment in the rice sectors; indirect production and consumption effects reflect increase in employment in non-rice sectors caused by 'backward' and 'forward' production linkages and household spending respectively. The size of consumption effects depends on the level of income generated from a technology as well as on its distribution of income among household classes having different marginal propensities to consume. The results of the paper show that the employment increase brought about by new technology depends importantly on the consumption effect. Thus the increase in total employment in irrigated regimes obtained from using power tillers instead of carabao results from positive consumption effects that are much greater than the negative direct effect. In constrast the consumption effect is much weaker in rainfed systems and is itself offset by the negative direct effect so that total employment declines with an increase in mechanization.

A change from hand to mechanical threshing or a substitution of power tiller and small thresher by tractor and large thresher that diverts income from hired labor to other classes gives negative consumption linkages in all water regimes. Total employment declines when positive production effects arising from backward and forward linkages and negative production effect caused by import substitution in the manufacture of agricultural inputs are incorporated with consumption effects. However, a comparison across water regimes reveals that the decline in employment arising from mechanization can be alleviated by more intensive irrigation characterized by high productivity, income and equity. The analysis shows that consumption effects may either offset or reinforce the initial change in employment. One important result obtained from the study is that the higher the level of mechanization, the greater is the consumption effect on employment expansion from an improvement in irrigation.

Most past studies on the employment impact of mechanization have implicitly ignored the indirect production and consumption aspects of technological change in agriculture. Because of its sheer size, the agricultural sectors offers opportunities for employment expansion through changes in consumption expenditures arising from substitution among alternative production technologies. The contention that agriculture possesses weak linkages is partly the result of aggregation. For relatively traditional agriculture in a state of low equilibrium that relies on on-farm biological processes, agricultural production might induce low consumption and production linkages, but this is not true for the high-income modern farm sector.

The implications of such a redirection of analysis are far-reaching: they include (1) policies to encourage equitable distribution of the gains from agricultural modernization, (2) policies

to encourage production of food grains, small manufacturers and services of daily need and (3) policies to encourage labor-intensive production techniques in agricultural and industrial sectors. They also involve the need to recognize the interdependence between sectors as well as the capacity of individual sectors to react to an increase in demand arising from a given agricultural programme. Inducing and strengthening the growth linkages can accelerate the process of agricultural transformation and, thereby, lead to self-sustaining growth in developing countries led by the modernizing agricultural sector.

FOOTNONES

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

[2] ILO (1970) mission report on Columbia recognizes the importance of import substitution in consumption as a determinant of employment.

[3] Unlike other primary activities, rice production has a perfectly elastic supply. This exception is dictated by our method of model simulation -- an exogenous increase in rice consumption met from a given sub-sector.

[4] The vector of household consumption is excluded from our first set of relationships and household consumption is added to the final demand vector F.

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

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

Table 2. Descriptions of five agricultural machinery manufacture sectors.

Sub-sectors	Type of machinery	Descriptions	Horse power	Cost of farmers (Peso)*
1	Power tiller	2-wheel with steering clutches and attachments	6-8	13,000
2	Tractor	4-wheel	35	120,000
3	Irrigation pump	4" Ø axial flow propeller	5	6,000
4	Portable thresher	TH6-IRRI design without oscillating screen	7	8,000
5	Large axial flow thresher	TH8-IRRI design with cleaner	12	17,000

* 7.5 pesos equal 1 US dollar.

Table 3. Employment effect of mechanization corresponding to a 1 percent change in consumer expenditure of rice (Peso 99.3 million) from one sub-sector to another.*

Change examined of rice production	Change in employment (thousand man years)*											
	Rainfed				Gravity irrigation				4" pump irrigation			
	Direct	Indirect Production	Indirect consumption	Total	Direct	Indirect Production	Indirect consumption	Total	Direct	Indirect Production	Indirect consumption	Total
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Carabao to power tiller	-0.92 (-0.80)	0.525 (0.460)	0.075 (0.046)	-0.320 (-0.294)	0.93 (-0.83)	0.776 (0.563)	1.286 (1.177)	1.132 (0.910)	-1.10 (-.83)	0.809 (0.626)	1.271 (1.111)	0.98 (0.907)
Hand threshing to small thresher	-3.15 (-2.703)	0.195 (0.156)	-0.936 (-.748)	-3.891 (-3.295)	-2.96 (-1.968)	0.206 (0.171)	-0.019 (-.004)	-2.773 (-1.801)	-2.11 (-1.06)	0.781 (0.635)	-0.012 (-0.003)	-1.341 (-.428)
Power tiller and small thresher to tractor and large thresher	-1.32 (-1.026)	-0.228 (-0.140)	2.216 (-1.362)	-3.764 (-2.528)	-0.89 (-0.53)	-0.217 (-.134)	-0.135 (-0.206)	-1.292 (-0.87)	-1.00 (-0.68)	-0.138 (-0.124)	0.675 (0.603)	-0.462 (-0.203)

* Value in the parenthesis refer to results obtained from the modified version of the model.

Table 4. Employment effect of irrigation corresponding to a 1 percent change in consumer expenditure of rice (Peso 99.3 million) from one sub-sector to another.

Change examined in rice production	Change in employment (thousand man-years)*															
	With carabao				With power tiller				With power tiller and small thresher				With tractor and large thresher			
	Direct	Indirect		Total	Direct	Indirect		Total	Direct	Indirect		Total	Direct	Indirect		Total
		Product-ion	Consumpt-ion			Product-ion	Consumpt-ion			Product-ion	Consumpt-ion			Product-ion	Consumpt-ion	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Upland to rainfed	4.90 (2.53)	0.160 (0.095)	6.74 (4.025)	11.80 (6.65)	-	-	-	-	-	-	-	-	-	-	-	-
Rainfed to gravity	3.00 (1.36)	0.160 (0.09)	10.81 (4.15)	13.97 (5.5)	2.99 (1.33)	0.411 (0.193)	12.02 (5.281)	15.42 (6.804)	3.18 (2.065)	0.422 (0.208)	13.94 (6.025)	16.54 (8.298)	3.61 (2.561)	0.433 (0.214)	14.97 (7.181)	19.01 (9.956)
Gravity to 4" pump	6.38 (3.20)	-0.09 (-0.04)	7.31 (5.09)	13.60 (8.25)	6.21 (3.20)	-0.057 (0.103)	7.30 (5.024)	13.45 (8.327)	7.06 (4.108)	0.518 (0.567)	6.77 (5.025)	14.34 (9.69)	6.95 (3.958)	0.597 (0.577)	7.62 (5.836)	15.17 (10.371)

* Values in the parenthesis refer to results obtained from the modified version of the model.

Table 5. Gross output and value added by sectors of the Input-Output table, 1978 (in millions of pesos and at producers' prices).

Sectors	Actual economy 1978		Gross output of sector when rice production is increased from specified sub-sectors*		
	Gross output	Value added	sub-sector 2 (carabao-rainfed-hand)	sub-sector 6 (carabao-gravity-hand)	sub-sector II (p. tiller-4" pump-hand)
(1) Rice (paddy production and milling)	19,984	8,554	19,142	19,239	19,235
(2) Agricultural crops, livestock, forestry and fishery	47,674	39,246	47,751	47,834	47,834
(3) Carabao service and activities	662	464	663	665	662
(4) Mining and quarrying	4,996	3,374	4,994	5,020	5,020
(5) Processed foods	42,304	14,399	42,354	42,464	42,453
(6) Sugar milling and refining	7,896	2,698	7,897	7,914	7,913
(7) Textiles and footwear	14,660	4,130	14,686	14,707	14,706
(8) Lumber and wood products	6,669	1,896	6,644	6,673	6,672
(9) Paper products and printing	3,723	1,859	3,728	3,736	3,736
(10) Leather products	134	62	132	133	132
(11) Rubber products	1,281	442	1,279	1,286	1,285
(12) Fertilizer	1,394	427	1,393	1,403	1,403
(13) Chemicals	9,574	3,171	9,584	9,614	9,612
(14) Petroleum products	11,221	3,815	11,225	11,259	11,257
(15) Cement	2,664	700	2,659	2,671	2,670
(16) Other non-metallic mineral products	1,535	6,990	1,518	1,525	1,525
(17) Basic metal and metal products	10,320	3,490	10,307	10,325	10,319
(18) Agricultural machinery	367	191	372	374	374
(19) Machineries except electrical and miscellaneous manufactures	2,087	1,135	2,084	2,094	2,095
(20) Electrical machinery and apparatus	2,580	1,223	2,510	2,522	2,521
(21) Transport equipment	3,938	2,206	3,933	3,951	3,946
(22) Electricity	3,223	1,467	3,220	3,236	3,233
(23) Gas manufacture and distribution	17	8	31	31	31
(24) Water services	337	176	339	341	341
(25) Construction	21,796	12,605	21,756	21,799	21,889
(26) Trade	32,350	26,566	32,531	32,588	32,568
(27) Banking and other financial institutions	16,372	13,390	16,425	16,453	16,445
(28) Transport services	14,336	8,284	14,357	14,375	14,371
(29) Medical, health and education	4,555	2,817	4,551	4,574	4,571
(30) Other business services	23,612	11,898	23,648	23,655	23,641
TOTAL	310,358	170,477	311,171	312,461	312,460

* Peso 99.3 million increase in consumer met from the specified sub-sector.

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