Poverty and Welfare Effects of Technical Change: A General Equilibrium Analysis for Philippine Agriculture*

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Abstract
In this study we address the impact that technical change in the agricultural sector of a developing country has on poverty alleviation and aggregate welfare. A small general equilibrium model of a price-taking economy is used to simulate several stylized forms of technical progress. Their effects are traced through changes in factor and commodity prices to the real expenditures of household groups classified both by their sources of income and by their patterns of consumption. For a given poverty line, we identify changes in the prevalence and nature of poverty using several different measures. Changes in aggregate economic welfare are evaluated using alternative sets of welfare weights. We show how the economic components of an observed change in poverty can be isolated to expose the roles of intersectoral linkages and changes in relative commodity prices. In concluding, we draw out some of the implications of our methodology for policy formulation.

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1. Introduction

In recent years all of the ASEAN[1] countries but one have recorded rapid rates of growth in per capita income accompanied by dramatic reductions in the proportion of households classified as being in poverty. The exception is the Philippines (Table 1). The absolute deprivation experienced by about half the Philippine population is regarded by most observers as a major source of political as well as economic instability. Since it came to power in 1986, the administration of Philippine Corazon Aquino has regularly declared the alleviation of poverty to be a prime objective of Philippine government policy.[2] The economic performance of the Philippine agricultural sector is central to poverty alleviation. As in most poor countries, agriculture in the Philippines is the largest sector in employment terms, accounting for more than 50% of the labour force (World Bank 1988). Moreover, the rural population includes a disproportionately large number of poor families.

In the early postwar years, the pressure exerted on agricultural land resources by rapid population growth was vented by internal migration and the opening of new land for cultivation. The cultivable land frontier was reached some time during the 1960s, and technical change became the primary means of intensifying agricultural production. Technical progress has taken two main forms: land quality improvement through irrigation, and the development of new biological and chemical technologies in cereal production. The latter are dominated by the high-yielding rice varieties (now called modern varieties or MVs) of the green revolution. These two forms of technical progress are closely linked. The yield advantage of modern over traditional rice varieties relies greatly on the availability of irrigation. Yield gains from adoption of MVs on rainfed or upland farms are only a small fraction of those on irrigated farms.

The phenomenon of differential rates of technical change within the agricultural sector and its implications for income distribution has received sporadic attention in the development economics literature (Falcon 1970; Quizon and Binswanger 1986). In an earlier study (Coxhead and Warr, forthcoming), we examined the effects of technical progress in agriculture when land - which is immobile between sectors - is heterogeneous in quality. We constructed a stylized general equilibrium model in which agricultural production took place in two sectors distinguished by their access,or lack of it, to irrigation, and traced the income distributional effects that differential rates

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[1] Association of South-East Asian Nations: Brunei, Indonesia, Malaysia, Philippines, Singapore and Thailand.
[2] Soon after taking office in 1986 the then Finance Minister Jaime Ongpin announced that "our first concern and priority is the problem of mass poverty and unemployment" (*Far Eastern Economic Review*, 6 November 1986).

of technical progress in the two sectors have on several groups of households distinguished by their ownership of factors and their patterns of consumption.

The Philippine government has declared that both the absolute and the relative well-being of households are appropriate policy targets.[3] In this paper we increase the dimensions of our earlier model to capture the effects of technical progress not only between household groups, but by expenditure classes within each group. Using a recently developed class of poverty measures due to Foster, Greer and Thorbecke (1984) we generate measures of changes in the prevalence of poverty which are functions of changes in real household expenditures. Since the latter are in turn determined by changes in relative factor and commodity prices as well as by changes in exogenous variables such as the rate and bias of technical progress, our results are more amenable to policy formulation for poverty alleviation than are those of most previous computable general equilibrium (CGE) models, which are in the main capable of providing information only on changes in the size distribution of income (see, for example, Adelman and Robinson 1978). Moreover, our analysis decomposes poverty changes into their economic components - adjustments in factor and commodity markets - which reveals the economic mechanisms by which poverty alleviation is achieved. This technique also serves to reduce the 'black box' nature of simulation results obtained using CGE models.

The next section describes our basic CGE model. Section 3 reviews poverty and welfare measures, and section 4 summarises our treatment of technical change. Section 5 presents our results.

2. The model

The model belongs to the Johansen class of general equilibrium models. Like all such models, it is linear in percentage changes of variables. It describes a small open economy in which three commodities are produced in four sectors. Two sectors produce a composite agricultural good; they are distinguished by their access to irrigation. The third and fourth sectors produce services and manufactures. By assumption, agricultural and manufactured goods are traded internationally at world prices, while the output of the third

3 Expressions of the need to alleviate poverty - not only for its own sake, but also as a means of stimulating domestic production - permeates the Philippine Medium Term Development Plan 1987-1992 (National Economic and Development Authority 1988). For example: "Philippine development efforts in 1987-92 shall be principally directed toward the following goals: (a) alleviation of poverty, (b) generation of more productive employment, (c) promotion of equity and social justice, and (d) the attainment of sustainable economic growth" (p.11). "A concerted attack against poverty is planned in the next six years. The economic recovery and the sustained growth targeted in the medium term will be achieved through policies, programs and projects that shall likewise ensure the promotion of social justice and the alleviation of poverty. Moreover, the main focus of government operations shall be the provision of basic needs of the population to ensure that these do not fall below minimum requirements" (p.32).

sector (services) is non-tradable, its price being determined entirely by domestic demand and supply. Each sector employs labour and capital, which are mobile across sectors, and a specific factor, which is immobile across sectors. The specific factors in the two agricultural sectors are their endowments of land, which is irrigated in sector 1 and non-irrigated in sector 2. Factors specific to the services and manufacturing sectors (sectors 3 and 4) may be thought of as plant, buildings and other "bolted down" capital not transferable in the short run.

Flexible functional forms are used to describe factor demand and product supply relations in each sector. These are given as equations (A1) to (A3) in Table 2. The parameters of these equations were estimated from Philippine data by Coxhead (1989). Equations (A4) and (A5) describe aggregate supplies of the mobile factors. For both labour and capital, changes in supply are determined both by changes in their own price (weighted by the appropriate elasticities) and by exogenous increases in endowments. Equations (A6) to (A11) determine changes in the prices of commodities and both specific and mobile factors. Constant returns to scale imply zero pure profits in production (equations (A6) - (A8)); satisfaction of these conditions determines changes in the prices of each sector's specific factor.

Changes in the prices of the non-tradable good and of mobile factors are established by the market clearing conditions (A9) - (A11). The *nominal* prices of the two tradable commodities are held constant throughout our analysis. World prices are are assumed to be constant, along with any subsidies, tariffs or other taxes which may be present in the domestic markets for these goods. Changes in the *relative* prices of the tradable goods are transmitted through changes in the nominal price of the non-tradable good: a rise (fall) in this tradable/non-tradable price ratio is thus what is sometimes described as a *real depreciation (appreciation)*, or a rise (fall) in the *real exchange rate* (Corden and Neary 1982).

The domestic markets for these two tradable goods clear jointly: a joint market clearing condition - the trade balance constraint - links changes in the excess supply of one good (exports) to changes in the excess demand for the other (imports). Walras' law states that provided consumers operate on their budget constraints, one of the two commodity market clearing conditions - the trade balance constraint and the market clearing condition for the non-tradables - is redundant. Either of these equations may be deleted; but the economic properties of the model will be the same regardless of which is chosen. For the purposes of this analysis it is analytically convenient to retain the market-clearing condition for the non-tradable (A9) and to suppress the trade balance constraint.

The fourth group of equations describes households' incomes and expenditures, which determine changes in poverty. Each household is endowed with a bundle of factors which it supplies to the market. Its income (equation (A12)) consists of market-determined returns on those factors. Because each household has a (potentially) unique consumption bundle, it also has a unique consumer price index (A13). Household incomes are exhausted in the purchase of commodities (A15). Since the only nominal commodity price to change in this model is that of the non-tradable, changes in tradables' nominal prices do not appear in the equations for the changes in the household price indices (A14) or the changes in consumer demand (A15).

The model distinguishes seven groups of households, classified both according to their factor endowments and their initial income levels. Since our focus is on technical change in agriculture we are most interested in changes in the relative and absolute welfare of households whose incomes are primarily derived from agriculture. These agriculture-based household groups are labourers (*H*1), small farmers in each agricultural sector (*H*6 and *H*7), and landlords in each agricultural sector (*H*4 and *H*5). By construction, labourers' factor endowments consist only of mobile labour. The endowments of small farmers include labour, some agricultural land in their own sector, and some mobile capital. Landlords' endowments consist of land in their own sector, and some mobile capital. The remainder of the mobile capital, as well as the endowments of factors specific to the sectors producing the non-tradable and tradable non-agricultural goods respectively, is owned by the household groups *H*2 and *H*3. Factor endowments are summarised for each group in Table 3; the exact allocation of endowments to household groups is given by the parameters shown in Table 4.

Farmers and landlords derive their incomes partly from their ownership of intersectorally immobile land and partly from their endowments of mobile labour and capital. Because of the presence of land in this asset mix, the fortunes of farmers and landlords are partially, but not completely, tied to profitability in the sector containing their land.

Labourers do not share in the ownership of fixed assets; their incomes are affected by a change in a particular sector only insofar as it affects the economy-wide demand for their labour. Households owning specific factors outside agriculture - in services (H2) and manufacturing (H3) have asset ownership positions comparable with those of landlords in the agricultural sectors: although they derive some income from their ownership of mobile capital, the greater portion comes from returns to specific factors. Changes in sectoral profitability are thus the main determinants of changes in these households' absolute and relative prosperity.

There are nine income classes within each household group. The initial distribution of income within and across household groups is shown in Table 5 and Figure 1. These distributions are based on data from the Philippines' *Family Income and Expenditure Survey* for 1985. Our commodity classification implies that the budget share of the non-tradable commodity is a critical demand parameter for each group. Within each income class, the budget share of the non-tradable in household consumption is the same for all household groups. Within each household group, this parameter rises monotonically from the lowest to the highest income class.[4]

The two-way classification of households permits us to evaluate the effects of exogenous shocks on the distribution of income between household groups as well as across income classes for any given group. For example, a labourer household in the poorest income class has the same pattern of consumption as a small farmer household in the same class, and responds identically to *ceteris paribus* changes in the price of the non-tradable good. A rise in wages increases the *nominal* incomes of labourer households in all classes by an equal amount. Since each income class has a unique pattern of consumption, however, a rise in wages relative to the price of the non-tradable will have different effects on the *real* expenditures of the labourer household in the poorest income class relative to those of labourers in higher classes.

The division of household groups by both income and expenditure patterns allows us to assess the impact of an exogenous shock on the level of poverty within each group, as well as changes in the aggregate level of poverty and in the household composition of the poor population. In the next section we describe changes in poverty and in aggregate consumption in terms of changes in real household expenditures. After a brief review of recent developments in the measurement of poverty, we show how the equations describing these effects have been derived.

3. Poverty and welfare measures

3.1 Poverty measures

At the beginning of this century the prevailing definition of material poverty was one of a failure to meet basic nutritional and biological requirements for the sustenance of life (Rodgers 1984). Over time the predominant definition has moved away from this 'absolute' concept towards one in which *relative* welfare plays a major role. Economic growth has apparently been a major cause of this shift. In countries experiencing rapid growth and apparent reductions in the incidence of absolute deprivation,

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[4] Values of consumer demand parameters draw information from Pante (1979), Lluch, Powell and Williams (1977), and Kravis, Heston and Summers (1983).

poverty is increasingly defined in relative terms. As the threat of starvation recedes, questions of the distribution of income and opportunity assume greater importance, and the use of normative poverty measures sensitive to the distribution of income among the poor becomes attractive.

All poverty measures deem individuals or households to be in poverty if their incomes or expenditures fall below a given poverty line. However, they differ in the importance they assign to the degree to which those incomes or expenditures are below the poverty line. The most widely used measure of poverty, called the *headcount* measure (H), simply records the number of people or households in poverty as a fraction of the total population. If q is the number of the poor in a population of size n, then $H = q/n$.

While H is useful as a summary measure, it reveals nothing of the *severity* of poverty - that is, how far below the poverty line the poor actually live. Another popular univariate poverty measure, the so-called *poverty gap*, or sometimes the *income gap*, records the average amount by which the incomes of the poor fall short of the poverty line. For the incomes of poor households $y_1, ..., y_q$ and a given poverty line z, the average income gap I is defined as:

$$I = \sum_{i=1}^{q} \frac{z - y_i}{q^z}, \qquad (1)$$

where q^z is the number of households with incomes below the poverty line z. When expressed as a percentage of the poverty line, the poverty gap measures the proportion by which national consumption would have to rise in order to eliminate poverty - assuming that such a rise could be distributed to each poor household exactly in accordance with its income gap.

H and I are in a sense complementary. H captures the numbers of people in poverty but not its severity, while I measures the severity of poverty but is insensitive to the numbers involved. Neither measure is sensitive to the distribution of incomes among the poor; H and I are measures of *absolute* rather than *relative* poverty. Following A. K. Sen (1976), the requirements for a poverty measure sensitive to the numbers of the poor and the severity of poverty as well as to the distribution of income among the poor may be formalised in two axioms as follows:

1. *Monotonicity axiom:* A reduction in the income of any household below the poverty line must, other things being equal, increase the measure of poverty.
2. *Transfer axiom:* Any transfer of income away from a household below the poverty line to any richer household must, other things being equal, increase the measure of poverty.

It is readily seen that H violates both of these axioms. Since H measures only the number of households in poverty, a fall in the income of any household already below the poverty line leaves it unchanged, contrary to the requirement of axiom 1. Similarly, H is unaffected by a transfer of income from any poor household to any richer household, which violates axiom 2. From the point of view of the policy-maker, H is useful only insofar as it provides a point of comparison with earlier poverty estimates. When welfare policies are directed at both absolute and relative poverty, the change in H is an unsatisfactory measure of progress toward those targets.

It can be seen by inspection that the income gap measure I satisfies axiom 1 (a reduction in the income of a poor household will *ceteris paribus* increase I), but not axiom 2 (the measure is unaltered by any mean-preserving transfer of income among households below the poverty line). For example, a direct transfer from one poor household to another, less poor but still below the poverty line, will increase the first household's poverty gap by exactly as much as it will reduce that of the second household, leaving I unchanged. In addition, I is insensitive to any change in the numbers of poor households: if the population below the poverty line were duplicated with the same characteristics it would leave I unchanged (Ravallion and Huppi, 1989).

An additively separable measure proposed by Foster, Greer and Thorbecke (1984) incorporates H and I as special cases in a parametric class of poverty measures. For any homogeneous group let $y_1, \ldots, y_n$ be the incomes of households grouped in ascending order, q and z be the number of poor households and the poverty line as before, and define $g_i = z - y_i$ to be the income shortfall of the ith household. The FGT class of poverty measures $P_\alpha(y;z)$ is given by

$$P_\alpha(y;z) = \frac{1}{nz^\alpha}\sum_{i=1}^{q} g_i^\alpha . \qquad (2)$$

If $\alpha = 0$ then P_α reduces to the headcount measure H; if $\alpha = 1$ then P_α is the product of H and I, the income gap measure normalised by the number of households in poverty. When $\alpha = 2$ the FGT measure is sensitive to the distribution of income as represented by the squared coefficient of variation of income among the poor, C_p (Foster *et al* 1984:762):

$$P_2 = H[I^2 + (1 - I)^2 C_p^2] .$$

The FGT class of measures is consistent with Sen's monotonicity axiom for $\alpha > 0$, and with the transfer axiom for $\alpha > 1$. It is parametric in α, increasing values of which indicate progressively higher levels of "poverty aversion". As the value of α increases, P_α satisfies measurement criteria giving ever greater weight to the welfare of the poorest among the poor. For $\alpha > 2$, P_α satisfies Kakwani's *transfer sensitivity axiom*, which requires that the increase in the poverty measure caused by a transfer from a poor to a less poor household be less, the higher are the initial incomes of the two households (Kakwani 1987b). As the value of α becomes very large, P_α approaches a "Rawlsian" measure giving weight only to the poorest among the poor. Most empirical studies using the FGT class of measures adopt P_2 as their preferred measure.

In addition to the properties just described, the FGT class of measures is additively decomposable across groups in a population. For a population composed of m groups of households with group income vectors $y^1, \ldots, y^m$:

$$P_\alpha(y;z) = \sum_{j=1}^{m} \frac{n_j}{n} P_\alpha(y^j;z), \tag{3}$$

where n_j/n is the share of the jth group in total population. An increase in poverty in any single group - with no change in that of other groups - increases the overall poverty measure. The contribution of a change in the poverty of any one group to the change in the overall measure is given by the change in its poverty weighted by its share in total population. FGT remark that this decomposition "allows a quantitative, as well as qualitative, assessment of the effect of changes in subgroup poverty on total poverty" (Foster *et al.* 1984:764); the additive separability property permits not only *cardinal* but also *ordinal* statements about poverty in and among subgroups of a population. Table 6 shows our estimates of P_0, P_1 and P_2 in the Philippines by household group, based on two alternative poverty lines and computed from household expenditure data.

Expressed in percentage change form (represented by a caret over a variable, so $\hat{X} = dX/X$) where z is held fixed and the y_i terms are allowed to vary, the proportional change in the FGT class of poverty measures is:

$$\frac{dP_\alpha(y;z)}{P_\alpha} = \hat{P}_\alpha = -\alpha \sum_{i=1}^{q} \lambda_i^{\alpha} \left(\frac{y_i}{g_i}\right) \hat{y}_i \,. \qquad \alpha > 0. \tag{4}$$

The parameter λ_i stands for the poverty gap of the ith household relative to the aggregate poverty gap, raised to the power of α:

$$\lambda_i^{\alpha} = \left(\frac{g_i^{\alpha}}{\sum_i g_i^{\alpha}}\right) \qquad g_i > 0.$$

Because this class of model deals with small changes in the region of equilibrium, the headcount measure (P_0) is invariant with respect to changes in incomes or expenditures. Positive values of α yield percentage changes in the poverty measure which accord increasingly greater weight to changes in the incomes or expenditures of the poorest households.

3.2 Welfare Measures

The measurement of poverty is a special case of welfare analysis in which the welfare of each household above the poverty line is assigned a zero weight. In reality the alleviation of poverty is only one among many targets of policy. It is important, therefore, to consider the *aggregate* effects of technical progress (or any similar change) on the population. In the context of a more general evaluation of social welfare change, concern with poverty alleviation may be represented by manipulation of the weights assigned to households whose initial income or expenditure places them below the poverty line.

The most commonly employed aggregate measure of economic welfare is real gross national product. This may be computed as the sum over all households of real household income. It is obvious that the computation of *changes* in real GNP by this means gives a relatively higher weighting to changes in the incomes of rich households (Todaro 1981). Let W be national welfare, a function of the incomes of the n households be $y_1, ..., y_n$. Now write the proportional change in aggregate welfare as:

$$\hat{W} = \sum_{i=1}^{n} \omega_i \hat{y_i} \ , \qquad (5)$$

where $\omega_i = (\partial W/\partial y_i)(y_i/W)$, the elasticity of W with respect to y_i, may be interpreted as the welfare weight attached to a unit proportional change in the income of the ith household. Now consider the standard form of GNP measure, y, the sum of the incomes of the n households. Then $\omega_i = y_i/y$. If income is concentrated among the top few percent of households, then the GNP weights are larger for more wealthy households, and $\hat{W}$ is dominated by changes in the incomes of the wealthy. The poor may be no better off - or may even suffer real income declines - without markedly affecting the proportional change in W.

As a 'neutral' alternative to income weights, Todaro (1981) suggests the use of the shares of household groups in total population. For each decile of the income distribution, for example, each ω_i would take a value of 1/10. Such a weighting scheme treats the welfare of all households as of equal importance. Both this and the income weights measure of national income are considered in our model.

In the spirit of the FGT class of poverty measures, an alternative set of welfare weights yielding a poverty-oriented welfare measure could be derived directly from the poverty measures themselves, using the household income gaps (g_i, defined above) relative to the aggregate income gap, raised to the power of α:

$$\omega_i = \lambda_i^{\alpha} \qquad \alpha=1,2 \qquad (6)$$

These measures take *no* account of the welfare of households initially above the poverty line. For increasing values of α they assign greater weight to changes in the incomes of the poorest households. For $\alpha=1$ the growth weights depend only on the distance by which each poor household falls below the poverty line. These are the weights implied by the poverty measure P_1. The use of weights with $\alpha=2$ (corresponding to P_2) strengthens the 'social justice' orientation of the welfare analysis by further taking into account the distribution of income changes among poor households.

Using 1985 income data for deciles of the Philippine population, Figure 2 provides a graphical comparison of the values of welfare weights implied by the standard GNP aggregation, Todaro's "neutral" population weights, the normalised income gap measure P_1, and the distributionally sensitive measure P_2. Todaro's weights are constant for all deciles and the GNP weights increase in proportion to income. The distributional sensitivity of the P_2 weights relative to those based on P_1 can be seen by observing that the slope of the former curve increases for lower levels of income.

4. Technical change

Technical change alters product supply and factor demand directly in the sector to which the shock applies, and indirectly in all sectors through price and quantity adjustments in factor and product markets. The values of these changes are obtained by the requirement that changes in supply equal changes in demand in the markets for labour, capital and the non-tradable good. Since the model is oriented to the short run, changes in aggregate supplies of both mobile and specific factors are restricted to zero. Changes in the functional distribution of income can thus be read directly from changes in factor prices.

The technical change specification in the model is adapted from Quizon and Binswanger (1983). In their analysis the rate and the bias of technical change in sector s can be obtained from the values of the *factoral rates of technical change*, $\hat{A}_{is}$, for each factor i. The $\hat{A}_{is}$ terms are the percentage changes in factor demand due to technical progress, evaluated at constant prices and output:

$$\hat{A}_{is} = \frac{\partial X_{is}}{X_{is}} = \frac{\partial X_{is}}{\partial t}\frac{1}{X_{is}}, \qquad (8)$$

where X_{is} denotes the demand for factor i in sector s, and t denotes time. The *overall rate of technical change* $\hat{T}_s$ is the cost-share-weighted average of the $\hat{A}_{is}$ terms:

$$\hat{T}_s = \sum_{i=1}^{n} \theta_{is}\hat{A}_{is}\ , \tag{9}$$

where θ_{is} denotes the share of factor i in total costs in sector s. For ease of exposition, in our subsequent discussion the sector subscripts s will be suppressed. $\hat{A}_i$ and $\hat{T}$ are defined when output is held constant, as is the case in a cost function.

Quizon and Binswanger derive the following expressions for $\hat{E}_i$ and $\hat{E}_y$, the profit function counterparts of $\hat{A}_i$ and $\hat{T}$ above:

$$\hat{E}_i = \beta_{iy}\hat{T} + \hat{A}_z - \hat{A}_i \text{ ; and} \tag{10}$$

$$\hat{E}_y = \beta_{yy}\hat{T} + \hat{A}_z\ , \tag{11}$$

where β_{ij} is the elasticity of quantity i with respect to the price of j; in the case where i is an output (input), β_{ij} is an output supply (input demand) elasticity. $\hat{A}_z$ is the factoral rate of technical change of land, the fixed factor in the profit function. In our model the $\hat{E}_i$ terms and $\hat{E}_y$ in the agriculture sector supply and factor demand equations are replaced by the right hand sides of equations (9) and (10). Selecting values of the $\hat{A}_i$ terms and $\hat{T}$ permits the simulation of any combination of technical change rates and biases, as will now be shown.

Factor-neutral technical progress in any sector is characterized by equality of each of the factoral rates of technical change $\hat{A}_i$ and the overall rate of technical change $\hat{T}$. This equality implies the following changes in factor demand and output in that sector:

$$\hat{E}_l = \beta_{ly}\hat{T} \geq 0 \text{ ;} \tag{12a}$$

$$\hat{E}_k = \beta_{ky}\hat{T} \geq 0 \text{ ; and} \tag{12b}$$

$$\hat{E}_y = (\beta_{iy} + 1)\hat{T} \geq 0\ . \tag{12c}$$

Technical progress which substitutes capital for labour with no change in output or in the productivity of land ($\hat{A}_z = \hat{T} = 0$) yields

$$\hat{E}_l = -\hat{A}_l \leq 0\ ; \tag{13a}$$

$$\hat{E}_k = \frac{\theta_l}{\theta_k}\hat{A}_l \geq 0 \text{ ; and} \tag{13b}$$

$$\hat{E}_y = 0\ . \tag{13c}$$

These expressions show that the *ceteris paribus* effect of the capital-using bias of technical change is to reduce labour demand and raise capital demand.

Reversal of k and l subscripts will yield expressions for the effects of a capital-saving, labour-using bias.

The third illustrative technical change involves the substitution of labour for land, with no change in the rate of technical progress or in its bias with respect to capital ($\hat{A}_k = \hat{T} = 0$). Since land is a specific factor and constant returns to scale have been imposed, at constant prices any increase in land productivity automatically ensures an increase in output even though the physical land area remains unchanged. In this case the technical change shifters are:

$$\hat{E}_l = (\frac{\theta_l}{\theta_k} + 1)\hat{A}_z \geq 0 \; ; \qquad (14a)$$
$$\hat{E}_k = \hat{A}_z \geq 0 \; ; \text{ and} \qquad (14b)$$
$$\hat{E}_y = \hat{A}_z \geq 0 \, . \qquad (14c)$$

According to these definitions, the individual components of any technical change which both increases output and alters factor proportions can be isolated by applying shocks to individual variables: $\hat{T}$ for factor neutrality, $\hat{A}_l$ for labour-capital bias, and $\hat{A}_z$ for land-saving, labour-using bias. The non-neutral changes impart only pure factor substitution effects, but since the model is linear in percentage changes, either or both may be combined with the results for neutral change to simulate the effects of progress which both raises output and alters the proportions in which factors are demanded at constant prices. Any combination of technical progress and factor bias can be represented in the manner just described so long as the number of technical change variables ($\hat{T}$ and the $\hat{A}_i$ terms) in each sector is equal to the number of factors employed in that sector.

The effects of other combinations of factor bias and output increase could readily be specified; for the illustrative purpose served by this model, however, the three just described are adequate. In the experiments simulating unbalanced growth in agriculture, technical changes in sector 1 only are described,but an equivalent methodology applies to sector 2, since technical change mechanisms are algebraically identical in both sectors. The effects of a constant rate and bias of technical progress across both agricultural sectors are also presented and discussed below.

5. Solution procedure

The model is implemented using the GEMPACK software package (Codsi and Pearson 1988). In Table 2 the complete model is shown to consist of $4s + 4hc + 6$ equations and $5s + 4hc + 17$ variables. Since tradables' prices are assumed to be constant, their percentage changes are set to zero in the model's equations. Closure is achieved by specifying as exogenous the technical change shifters $\hat{E}_l$ and $\hat{E}_y$ and the endowments of capital, labour and fixed factors $\hat{K}$, $\hat{L}$, and $\hat{Z}_1$ to $\hat{Z}_4$. This leaves $4s + 4hc + 6$ endogenous variables and the same number of equations, permitting the model to be solved.

6. Results of technical change shocks.

We illustrate the model's properties by simulating a hypothetical ten per cent factor-neutral technical change "shock" in each agricultural sector. We also evaluate technical change shocks based on empirical estimates from Philippine agricultural data. The nature and magnitude of the hypothetical shocks are not intended to be exact representations of particular technical innovations in Philippine agriculture. Their analytical interest derives less from their magnitude or the types of new technologies they may represent than from the fact that they may be applied either uniformly to both agricultural sectors, or to only one of the two. This property permits *ex ante* examination of the differences in actual and potential productivity of irrigated and non-irrigated areas, and the implications of such differences for poverty and aggregate real income.

Table 7 shows the effects of neutral technical change shocks in both agricultural sectors on the demand for mobile factors, sectoral output levels, and the real prices of factors and the non-tradable commodity. Since demand for the agricultural good is elastic, output and mobile factor demands rise in the sectors experiencing technical change. The technical change shocks bring about a *real appreciation* - a rise in the relative price of the non-tradable good. This increase, combined with the effects of increased spending on non-tradables out of the new income generated by technical progress, brings about a substantial increase in the price of the non-tradable good as well as an increase in its output. The manufacturing sector, by contrast, loses first from a decline in the relative price of its output, and second from rises in mobile factor prices: its output thus falls. The transmission of the effects of the technical change shock in agriculture to other sectors is equivalent to that analysed for the cases of resource discoveries in 'booming sector' economic analyses (Corden and Neary 1982; Cassing and Warr 1985).

The neutral technical change shocks affect poverty in two ways: by raising aggregate income and by altering the distribution of income and expenditure. Table 8 shows relatively large poverty reductions among labourers, owners of the factor specific to the non-tradable (services) sector, and landlords and farmers owning land in the sectors in which the shocks take place. Owners of factors specific to the tradable manufacturing sector, and landlords and farmers in the agricultural sectors not experiencing technical change, experience increased poverty.

Labourers' gains are derived primarily from real wage rises; however, since most labourer households fall near the lower end of the income distribution and therefore spend a smaller fraction of their incomes on the non-tradable good, growth in their real incomes is reduced less by the rise in the price of the non-tradable than is that of more wealthy household groups.

Because these shocks occur in relatively labour-intensive sectors of the economy, wages rise relative to returns to mobile capital. This translates into substantial poverty reductions among farmer households, much of whose income is derived from the earnings of labour. Producers in the manufacturing sector are caught between rising input prices and falling relative output prices. This manifestation of the Stolper-Samuelson effect emerges as a large rise in poverty among owners of the factor specific to the manufacturing sector. Since they are a relatively small fraction of the total population, however, the contribution of their poverty to the change in aggregate poverty is slight. The very large reduction in poverty among the owners of factors specific to the sector producing non-tradables is due mainly to the real appreciation caused by the technical change shocks.

Simulations using the model were also conducted with values of the technical change parameters estimated from Philippine agricultural data (Coxhead 1989). The short-run overall rate of technical change in irrigated agriculture (represented by sector 1) exceeded that for non-irrigated agriculture (sector 2) by a factor of 20 - in fact, the estimated overall rate of technical progress in the latter sector was almost zero. Technical progress in irrigated agriculture was found to have been strongly labour-saving and land-saving, due to the combined effects of adoption of 'green revolution' biological technologies and extensive mechanization of agricultural production during the period under study. By contrast, in unirrigated agriculture technical change was found to have been weakly labour-using and weakly land-saving. Accordingly, the simulation results reported in Table 9 show a smaller rise in wages relative to returns to mobile capital, and a large fall in the real rate of return to agricultural land in sector 2. Poverty changes derived from these results suggest that rapid technical progress in irrigated agricultural areas actually *increased* poverty in unirrigated areas, most particularly for owners of land specific to that sector (Table 10, column 5).

The general equilibrium approach employed in this model exposes the intersectoral, indirect effects of a change (such as technical progress) directly affecting only one sector. We can demonstrate the operation of intersectoral linkages by separating the changes in the endogenous variables into their components due to factor market adjustments, changes in demand for the non-tradable good, and changes in the relative prices of non-tradable and tradable goods.

The direct effect that a particular shock has on factor markets - at constant commodity prices - is found by constraining the change in the price of the non-tradable good to be zero. The *resource movement effect* is the sum of the factor market adjustments so obtained, and the effects of the shock on the price of the non-tradable *net* of the effects of increased consumer spending arising from the shock. This is found by computing the effects of the shock with the expenditure elasticity of demand for the non-tradable (η) set to zero. The *spending effect* of the shock - changes due to increased consumer demand from the rise in income - is found by assuming that the shock has no effect on factor demands within the sector to which it applies. It is calculated as the difference between the resource movement effect and the total effect of the shock.

Table 10 reports the results of this decomposition for the technical change shocks computed from empirically estimated parameters. Results are shown for the two poverty measures P_1 and P_2. In both cases a little over half of the total reduction in aggregate poverty is due to the resource movement effect, and the remainder to the spending effect. The standard set of assumptions employed in single-sector models of technical progress or other change rules out changes in mobile factor prices. Typically, these factors are assumed to be supplied to the sector at a constant price. A general equilibrium treatment allows this assumption of infinitely elastic factor supply to be dropped. The implications are very significant.

Our results show that by ignoring the resource movement effect such a partial equilibrium treatment would slightly underestimate the extent of poverty reduction due to technical progress of the type considered here. More importantly, the partial equilibrium estimates yield a picture of the distribution of poverty changes very different from those provided by the general equilibrium estimates. The former underestimates the extent of poverty reduction among owners of intersectorally mobile factors (especially labourers and small farmers) and greatly overestimates that among owners of factors specific to non-agricultural sectors. The potential distortion in a partial equilibrium analysis is even greater if we consider the effects of the technical change only on those households whose income is derived primarily from agriculture, by excluding the results for households *H*2 and *H*3. The partial equilibrium estimates would then suggest that the technical change led to an *increase* in aggregate poverty, whereas the general equilibrium estimates would suggest a *decrease.*

Measures of change in aggregate economic welfare (as described in equation (5)) for a technical change shock based on 'actual' values are shown in Table 11. The total general equilibrium welfare gain using population share weights (2.8%) is nearly twice as large as the gain computed using standard GNP share weights (1.6%). Welfare gains computed using the poverty weights are about three times greater than the population share weighted gain. To policy-makers for whom poverty alleviation and 'social justice' have high priority, these (or related) alternative weighting methods for the measurement of aggregate welfare changes could provide useful summary statistics in the *ex ante* evaluation of competing policy choices. Partial equilibrium estimates of the welfare gains due to technical change - also presented in Table 11 - fail to capture factor price effects. Since it is these effects which dominate the welfare changes, the partial equilibrium estimates understate welfare gains regardless of which set of weights is used. Moreover, the welfare gain measured using poverty weights is trivially small by comparison with the results obtained with other weighting schemes.

7. Conclusions and policy implications.

Observed general equilibrium changes in poverty are due substantially to changes in relative factor prices, and in the relative prices of the non-tradable and tradable commodities. Many prices - especially commodity prices[5] - are the actual or potential instruments of government policy. Some of these are instruments aimed directly at the alleviation of poverty - food price ceilings, for example - whereas others (such as trade restrictions) appear to have no direct relationships with the incidence of poverty. By exposing both the direct and indirect effects of price changes on real household expenditures a model such as that presented in this paper can assist policy-makers to evaluate not only the efficacy of explicit poverty alleviation programs, but also to recognise the poverty linkages of interventions which are not related in an obvious way to the incidence of poverty.[6]

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[5] In the Philippines, the government either controls or exerts substantial influence of the prices of many important consumer items, including rice and other staple cereals, meat, cooking oil, electricity and petroleum products.

[6] Note that in our model, a neutral technical change in a sector has effects equivalent to those of a change in the price of the commodity produced in that sector.

The type of analysis illustrated in this study can also help to quantify the costs of alternative poverty alleviation programs - explored in detail by Kanbur 1987 - and conversely to quantify the *poverty* costs of alternative policies only indirectly related to poverty. Moreover, this modeling exercise can shed light on a particularly vexing problem, that of the imperfect targeting of poverty alleviation instruments. This well-known problem stems from the fact that the benefits of most poverty alleviation measures are not captured only by poor families. Food subsidies, for example, reduce prices for all consumers, including the rich. Targeting through means tests or other measures is generally prohibitively expensive or open to corruption. A carefully specified general equilibrium model can help provide *ex ante* indications as to which policy instruments might best target specific groups.

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Table 1: GNP growth and poverty trends in ASEAN nations.

Country	Annual GNP Growth 1965-1986 (%)	Year	Poverty incidence Rural	Urban	Total
Indonesia	4.6	1976	40.4	38.8	40.1
		1978	33.9	30.8	33.3
		1980	28.4	29.0	28.6
		1981	26.5	28.1	26.8
		1984	21.2	23.1	21.6
Peninsular Malaysia	4.3	1957-58	59.6	29.7	51.2
		1970	58.7	21.3	49.3
		1979-80	37.4	12.6	29.0
		1983	41.6	11.1	30.3
Philippines	1.9	1971	57.4	35.1	50.7
		1980	46.7	28.5	40.8
		1983	45.4	26.0	39.0
		1985	42.5	33.2	48.1
		1988[a]	n.a.	n.a.	49.0
Singapore	7.6	1953-54	-	19.2	19.2
		1972-73	-	7.0	7.0
		1977-78	-	1.5	1.5
		1982-83	-	0.3	0.3
Thailand	4.0	1962-63[b]	61.0	38.0	57.0
		1968-69[b]	45.0	25.0	42.0
		1975-76[b]	37.0	22.0	33.0
		1981[b]	34.7	21.1	31.3
		1988[b]	30.6	8.6	25.2

n.a. not available

Sources: (GNP growth) World Bank: *World Development Report 1988;*

(Poverty) Rao (1988), except [a] Philippine goverment figures cited in *Far Eastern Economic Review*, 12 July 1990, and [b] Krongkaew 1990.

Table 2: Equations in the Model

Expression[a]	*No of Equations*	*Equation Number*
1. Factor demand and product supply		
$\hat{L}_s = \beta^s_{ll}\hat{w} + \beta^s_{lk}\hat{r} + \beta^s_{ly}\hat{P}_s + \beta^s_{lz}\hat{Z}_s + \hat{E}_{ls}$	(*s*)	(A1)
$\hat{K}_s = \beta^s_{kl}\hat{w} + \beta^s_{kk}\hat{r} + \beta^s_{ky}\hat{P}_s + \beta^s_{kz}\hat{Z}_s + \hat{E}_{ks}$	(*s*)	(A2)
$\hat{Y}_s = \beta^s_{yl}\hat{w} + \beta^s_{yk}\hat{r} + \beta^s_{yy}\hat{P}_s + \beta^s_{yz}\hat{Z}_s + \hat{E}_{ys}$	(*s*)	(A3)
2. Factor supply		
$\hat{L} = \varepsilon_l\hat{w} + \hat{\bar{L}}$	(1)	(A4)
$\hat{K} = \varepsilon_k\hat{r} + \hat{\bar{K}}$	(1)	(A5)
3. Price setting and market clearing		
$0 = \theta_{ls}\hat{w} + \theta_{ks}\hat{r} + \theta_{zs}\hat{z}_s - \hat{T}_s$ (*s*=1,2) $\hat{P}_3 = \theta_{l3}\hat{w} + \theta_{k3}\hat{r} + \theta_{z3}\hat{z}_3$ (*s*=3) $0 = \theta_{l4}\hat{w} + \theta_{k4}\hat{r} + \theta_{z4}\hat{z}_4$ (*s*=4)	(*s*)	(A6-8)
$\hat{Y}_3 - \hat{C}_3 = 0$	(1)	(A9)
$\hat{L} - \sum_s \lambda_{ls}\hat{L}_s = 0$	(1)	(A10)
$\hat{K} - \sum_s \lambda_{ks}\hat{K}_s = 0$	(1)	(A11)
4. Household income and expenditure (each of c income classes)		
$\hat{M}_h = \delta_{hl}(1+\varepsilon_{hl})\hat{w} + \delta_{hk}(1+\varepsilon_{hk})\hat{r} + \sum_{s=1}^{4}\gamma_{hs}(\hat{z}_s + \hat{Z}_s)$ $+ \delta_{hl}\hat{\bar{L}} + \delta_{hk}\hat{\bar{K}}$	(*h*)	(A12)
$\hat{P}_h = \mu_{h3}\hat{P}_3$	(*h*)	(A13)
$\hat{R}_h = \hat{M}_h - \hat{P}_h$	(*h*)	(A14)
$\hat{C}_{h3} = \xi_{h3}\hat{P}_3 + \eta_{h3}\hat{M}_h$	(*h*)	(A15)
$\hat{C}_3 = \sum_h \psi_h\hat{C}_{h3}$	(1)	(A16)
Total number of equations	*4s + 4hc + 6*	

Table 2 (cont'd): Variables and Parameters in the Model

Symbol	*Definition*	*Number of equations*
Endogenous variables		
L_s	Labor demand in sector *s*	(*s*)
K_s	Capital demand in sector *s*	(*s*)
Y_s	Product supply in sector *s*	(*s*)
L	Aggregate labor supply	(1)
K	Aggregate capital supply	(1)
M_h	Income of household group *h*	(*hc*)
P_h	Expenditure share-weighted price index of household group *h*	(*hc*)
R_h	Real income of household group *h* (M_h/Γ_h)	(*hc*)
C_{h3}	Demand for good 3 by household group *h*	(*hc*)
C_3	Aggregate demand for good 3	(1)
w	Price of labor	(1)
r	Price of capital	(1)
z_s	Return to specific factor in sector *s*	(*s*)
P_3	Price of non-traded good (good 3)	(1)
	Total endogenous variables	$4s + 4hc + 6$
Exogenous variables		
Z_s	Endowment of fixed factor specific to sector *s*	(*s*)
$\bar{L}$	Aggregate labor endowment	(1)
$\bar{K}$	Aggregate capital endowment	(1)
E_{is}	Technical change shifter[a] for factor *i* in agricultural sector *s*	(4)
E_{ys}	Technical change shifter[a] for output in agricultural sector *s*	(2)
T_s	Overall rate of technical change[a] in agricultural sector *s*	(2)
	Total exogenous variables	$s + 11$
Total number of variables		$5s+4hc+17$

Table 2 (continued)

Symbol	*Definition*
Numeraire price	
P_1	Price of agricultural good
Parameters	
θ_{is}	Share of factor i in total costs of production in sector s
β^s_{ij}	Elasticity of demand for factor i with respect to factor price j in sector s
β^s_{iy}	Elasticity of demand for factor i with respect to output price y in sector s
β^s_{iz}	Elasticity of demand for factor i with respect to fixed factor z in sector s
β^s_{yi}	Elasticity of supply of good y with respect to factor price i in sector s
β^s_{yy}	Elasticity of supply of good y with respect to own price in sector s
β^s_{yz}	Elasticity of supply of good y with respect to specific factor z in sector s
λ_{is}	Employment share of factor i in sector s
ε_{hi}	Own-price elasticity of supply of factor i from household group h
ε_i	Aggregate own-price supply elasticity of factor i
δ_{hi}	Share of income of household group h derived from earnings of mobile factor i
γ_{hi}	Share of income of household group h derived from earnings of specific factor Z_s
μ_{h3}	Expenditure share of household group h on good 3
η_{h3}	Expenditure elasticity demand for good 3 by household group h
ϕ_{hi}	Share of household group h in ownership of factor i
ψ_{h3}	Share of household group h in consumer demand for good 3
ξ_{h3}	Price elasticity of demand for good 3 by household group h

Table 3: Household categories and characteristics

Code	*Description*	*Asset ownership*
H1	Laborers	Mobile labor only
H2	Service sector capitalists	Specific factor in sector 3; some mobile capital
H3	Manufacturing sector capitalists	Specific factors in sector 4; some mobile capital
H4	Landlords in irrigated area (sector 1)	Most irrigated land; some mobile capital
H5	Landlords in unirrigated area (sector 2)	Most unirrigated land; some mobile capital
H6	Small farmers in irrigated area (sector 1)	Some irrigated land; some mobile labour and capital
H7	Small farmers in unirrig. area (sector 2)	Some unirrigated land; some mobile labour and capital

Note: Exact quantities of factors owned by each group are shown in Table 4

Table 4: Factor ownership and factor shares in household incomes

H'hold Group[a]	Factor shares in household incomes						$\sum_i \delta_{hi} + \sum_i \gamma_{hi}$
	δ_{hl}	δ_{hk}	γ_{h1}	γ_{h2}	γ_{h3}	γ_{h4}	
H1	1.0	0.0	0.0	0.0	0.0	0.0	1.0
(ϕ_{1i})	*(0.4)*[b]	*(0.0)*	*(0.0)*	*(0.0)*	*(0.0)*	*(0.0)*	
H2	0.0	0.3	0.0	0.0	0.7	0.0	1.0
(ϕ_{2i})	*(0.0)*	*(0.2)*	*(0.0)*	*(0.0)*	*(1.0)*	*(0.0)*	
H3	0.0	0.3	0.0	0.0	0.0	0.7	1.0
(ϕ_{3i})	*(0.0)*	*(0.5)*	*(0.0)*	*(0.0)*	*(0.0)*	*(1.0)*	
H4	0.0	0.5	0.5	0.0	0.0	0.0	1.0
(ϕ_{4i})	*(0.0)*	*(0.1)*	*(0.7)*	*(0.0)*	*(0.0)*	*(0.0)*	
H5	0.0	0.4	0.0	0.6	0.0	0.0	1.0
(ϕ_{5i})	*(0.0)*	*(0.1)*	*(0.0)*	*(0.7)*	*(0.0)*	*(0.0)*	
H6	0.3	0.4	0.3	0.0	0.0	0.0	1.0
(ϕ_{6i})	*(0.3)*	*(0.05)*	*(0.3)*	*(0.0)*	*(0.0)*	*(0.0)*	
H7	0.4	0.2	0.0	0.4	0.0	0.0	1.0
(ϕ_{7i})	*(0.3)*	*(0.05)*	*(0.0)*	*(0.3)*	*(0.0)*	*(0.0)*	
$\sum_h \phi_{hi}$	*(1.0)*	*(1.0)*	*(1.0)*	*(1.0)*	*(1.0)*	*(1.0)*	

Note: δ_{hi} and γ_{hi} denote the proportion of the income of household *h* derived from ownership of mobile and specific factors respectively.

[a] Household groups (defined in text) are H1: laborers; H2: owners of sector 3's specific factor; H3: owners of sector 4's specific factor; H4: landlords in sector 1; H5: landlords in sector 2; H6: farmers in sector 1; and H7: farmers in sector 2.

[b] Figures in parentheses indicate ϕ_{hi}, the proportion of the economy's endowment of each factor *i* owned by household group *h*.

Source: See text.

Table 5: Population distribution by household group and income class

Household Group	Income Class (₱ 000 per annum, 1985 prices)									
	UNDER 6.0	6.0-9.9	10.0-14.9	15.0-19.9	20.0-29.9	30.0-39.9	40.0-59.9	60.0-99.9	100.0 and OVER	All Income Classes
	Relative Frequency (% Households)									
Laborers	0.95	3.49	5.57	4.28	4.90	2.46	1.65	0.61	0.10	24.01
NT capitalists	0.15	0.85	1.97	2.70	4.52	3.00	3.26	2.10	1.20	19.75
T capitalists	0.09	0.50	1.18	1.44	2.62	1.95	1.91	1.20	0.65	11.55
Landlords 1	0.32	0.70	0.96	0.97	1.65	1.26	2.02	1.63	1.13	10.65
Landlords 2	0.83	0.85	0.87	0.58	0.72	0.43	0.49	0.35	0.31	5.43
Farmers 1	0.14	1.27	2.51	2.60	2.91	1.25	0.89	0.30	0.08	11.96
Farmers 2	1.31	3.63	4.89	3.10	2.38	0.70	0.41	0.18	0.04	16.65
All Households	3.79	11.30	17.96	15.68	19.70	11.05	10.63	6.38	3.52	100.00

[a] Salaried workers and entrepreneurs in non-agricultural sectors

Source: *Family Income and Expenditure Survey 1985*

Notes:
1. Laborers households are defined as those whose primary sources of income are agricultural wages and salaries, rural non-agricultural wages and salaries and net receipts from family sustenance activities.
2. NT capitalists are those whose main sources of income are urban non-agricultural wages and salaries and non-agricultural entrepreneurial activities like wholesale and retail, community, social, recreational and personal services, transportation, storage and communication services and construction.
3. T capitalists are those whose main sources of income are urban non-agricultural wages and salaries and non-agricultural entrepreneurial activities like manufacturing, mining and quarrying and other entrepreneurial activities.
4. Landlords 1 are those whose main sources of income are those sources of income other than ages and salaries, entrepreneurial activities and net receipts from family sustenance in NCR and regions I - IV and XI.
5. Landlords 2 are those whose main sources of income are those sources of income other than wages and salaries, entrepreneurial activities and net receipts from family sustenance in regions V - X and XII.
6. Farmers 1 are those whose main sources of income are agricultural entrepreneurial activities in NCR and regions I - IV and XI.
7. Farmers 2 are those whose main sources of income are agricultural entrepreneurial activities in regions V - X and XII.

Table 6: Poverty by household group under alternative poverty line and poverty definitions.

Household Group	Z = ₱15,000			Z = ₱20,000		
	P_0	P_1	P_2	P_0	P_1	P_2
Laborers	0.4168	0.1265	0.0519	0.5950	0.2239	0.1020
NT capitalists	0.1506	0.0395	0.0142	0.2875	0.0885	0.0345
T capitalists	0.1534	0.0401	0.0144	0.2781	0.0877	0.0347
Landlords 1	0.1857	0.0631	0.0288	0.2770	0.1062	0.0506
Landlords 2	0.4690	0.1975	0.1052	0.5759	0.2735	0.1526
Farmers 1	0.3282	0.0870	0.0308	0.5485	0.1804	0.0734
Farmers 2	0.5911	0.1950	0.0859	0.7774	0.3172	0.1538
Total	0.3304	0.1031	0.0437	0.4872	0.1819	0.0834

Source: Computed from NEDA: *Family Income and Expenditure Survey 1985*

Table 7: Effects of neutral technical change shocks on factor demands, output and real prices

	Shock in		
Endogenous Variable	Sector 1	Sector 2	Both Sectors
Labor demand			
Agriculture 1	2.34	-0.99	1.35
Agriculture 2	-0.54	0.71	0.17
Services	1.89	0.59	2.48
Manufacturing	-3.21	-1.79	-5.00
Capital demand			
Agriculture 1	3.00	-0.95	2.05
Agriculture 2	-0.15	0.50	0.35
Services	5.01	2.39	7.40
Manufacturing	-4.09	-1.53	-5.62
Output supply			
Agriculture 1	13.69	-0.93	12.76
Agriculture 2	-0.49	11.56	11.07
Services	4.52	1.91	6.43
Manufacturing	-4.37	-2.02	-6.39
Real mobile factor prices			
Labor	1.28	0.79	2.07
Capital	0.79	0.31	1.10
Real specific factor prices			
Agriculture 1	15.05	-4.57	10.48
Agriculture 2	-7.85	16.36	8.51
Services	16.01	6.83	22.84
Manufacturing	-13.45	-6.11	-19.56
Real price of non-tradable	8.89	3.93	12.82

Table 8: Household poverty effects of neutral technical change shocks in sectors 1 and 2.

Household Group	Shock in Sector 1	Shock in Sector 2	Shock in Both Sectors
	Poverty measure = P_1		
Laborers	-5.75	-3.06	-8.81
NT capitalists	-35.69	-15.25	-50.94
T capitalists	22.68	10.40	33.08
Landlords 1	-18.07	3.17	-14.90
Landlords 2	4.57	-15.00	-10.43
Farmers 1	-17.87	1.36	-16.51
Farmers 2	2.64	-15.42	-12.78
All households	-9.19	-5.43	-14.62
	Poverty measure = P_2		
Laborers	-7.45	-3.95	-11.40
NT capitalists	-46.22	-19.75	-65.97
T capitalists	29.26	13.41	42.67
Landlords 1	-22.97	4.00	-18.97
Landlords 2	6.00	-19.86	-13.86
Farmers 1	-23.99	1.79	-22.20
Farmers 2	3.34	-19.88	-16.54
All households	-11.97	-7.05	-19.02

Table 9: Effects of estimated technical change shocks on factor demands, output and real prices

Endogenous Variable	Total Shock
Labor demand	
Agriculture 1	7.77
Agriculture 2	1.12
Services	0.04
Manufacturing	-7.32
Capital demand	
Agriculture 1	16.63
Agriculture 2	0.92
Services	4.68
Manufacturing	-6.70
Output supply	
Agriculture 1	18.60
Agriculture 2	0.29
Services	2.84
Manufacturing	-8.52
Real mobile factor prices	
Labor	5.18
Capital	3.34
Real specific factor prices	
Agriculture 1	1.85
Agriculture 2	-12.79
Services	13.42
Manufacturing	-23.82
Real price of non-tradable	11.36

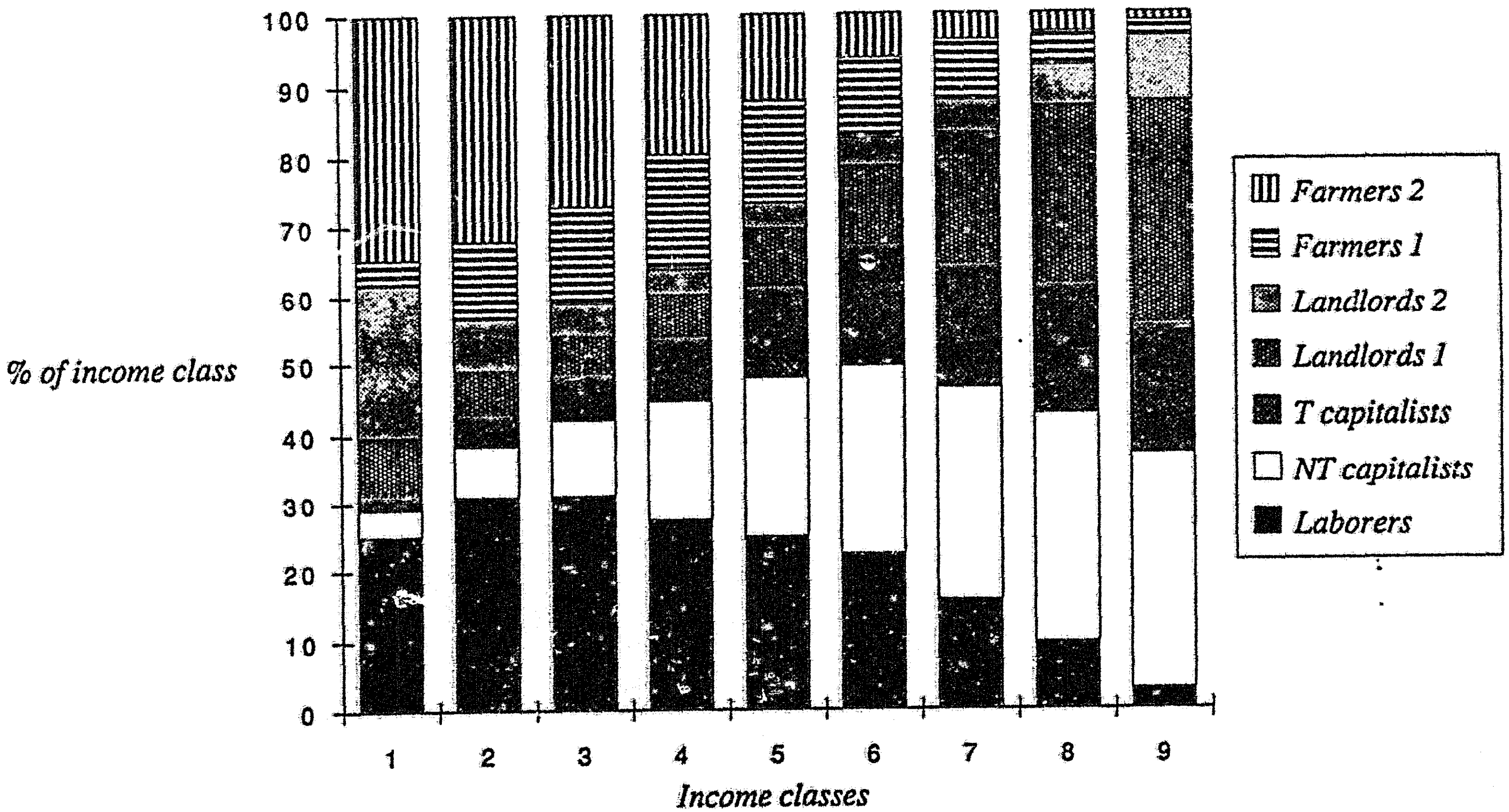
Table 10: Changes in poverty due to empirically estimated technical change shocks (%)

Household Group	*Resource Movement Effect*			*Spending Effect*	*General Equilibrium Estimate*	*Partial Equilibrium Estimate*
	Factor Markets (1)	*Real Apprec'n (2)*	*Total RM Effect (3)=(1)+(2)*	*(4)*	*(5)=(3)+(4)*	*(6)=(2)+(4)*
			Poverty Measure = P_1			
Laborers	-11.6	-1.7	-13.3	-2.3	-15.6	-4.0
NT capitalists	16.9	-21.3	-4.4	-29.3	-33.7	-50.6
T capitalists	15.9	10.3	26.2	14.0	40.2	24.3
Landlords 1	-15.8	3.2	-12.6	4.4	-8.2	7.6
Landlords 2	1.6	2.2	3.8	3.1	6.9	5.3
Farmers 1	-18.5	2.0	-16.5	2.7	-13.8	4.7
Farmers 2	-2.1	1.6	-0.5	2.3	1.8	3.9
All Households	-2.2	-3.0	-5.2	-4.1	-9.3	-7.1
			Poverty Measure = P_2			
Laborers	-14.9	-2.2	-17.1	-3.0	-20.1	-5.2
NT capitalists	21.9	-27.7	-5.8	-37.8	-43.6	-65.5
T capitalists	20.5	13.2	33.8	18.1	51.9	31.3
Landlords 1	-20.1	4.1	-16.0	5.6	-10.4	9.7
Landlords 2	2.2	2.9	5.1	4.0	9.0	6.9
Farmers 1	-24.8	2.6	-22.2	3.6	-18.6	6.2
Farmers 2	-2.7	2.1	-0.6	2.8	2.2	4.9
All Households	-2.8	-3.9	-6.8	-5.4	-12.2	-9.3

Table 11: Changes in aggregate welfare due to empirically estimated technical change shocks (%)

Weighting Assumption	*Resource Movement Effect*			*Spending Effect*	*General Equilibrium Estimate*	*Partial Equilibrium Estimate*
	Factor Markets (1)	*Real Apprec'n (2)*	*Total RM Effect (3)=(1)+(2)*	*(4)*	*(5)=(3)+(4)*	*(6)=(2)+(4)*
Standard GNP weights	0.5	0.5	1.0	0.6	1.6	1.1
Population weights	1.4	0.6	2.0	0.8	2.8	1.4
P_1 weights	7.9	0.1	8.0	0.1	8.1	0.2
P_2 weights	7.9	0.1	8.0	0.2	8.2	0.3

Figure 1: Distribution of households by income class



Source: Family Income and Expenditure Survey 1985. Household groups are defined in the text of the paper

Figure 2: Alternative proportional welfare weights for Philippine income data.