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INTERRELATIONSHIPS BETWEEN AGRICULTURAL STRATEGY AND RURAL INCOME DISTRIBUTION†

The prospect of a rapidly growing labor supply in the 1970s, the experience of limited labor absorption in the industrial sector, and the onset of capital intensification even in agriculture give urgency to consideration of agricultural strategies which will increase both distributional equity and production in the developing countries. This study examines the income distributional implications of alternative agricultural policies. It gives special attention to land redistribution, the policy most likely to increase both output and equity; improved seeds *cum* fertilizer, the instrument of greatest current production impact, and farm mechanization, the policy most likely to concentrate rural income. The new empirical estimates presented refer to rural savings as related to income distribution, and to net effects of mechanization on yields. For further empirical evidence on equity effects of alternative policies, the study draws on previous research by the author and on the general literature.

POLITICAL AND MACROECONOMIC CONSIDERATIONS

Political Structure

The political structure is the principal determinant of the effects of alternative agricultural policies on income distribution. Most policy instruments can increase or decrease income concentration, depending on the implementation chosen. In the absence of a specific commitment to improving rural equality, the benefits of government policies tend to accrue to rich farmers in proportion equal to or greater than their share in agricultural production. This profile of benefits occurs because the government favors its more important clients and the upper income farmers have greater access to credit and improved inputs because of their greater collateral.

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Employment Growth

The principal macroeconomic fact likely to affect rural income distribution in the 1970s is the expected rapid growth of the labor force in the developing countries. This growth is estimated as 2.3 percent annually in the decade of the 1970s, compared with 1.7 percent annual growth in the period 1950–65 (*38*, p. 31). The failure of the manufacturing sector to achieve employment growth rates as high as urban population growth rates is well known (see, for example, *1* and *18*). Reasons for the divergence include factor price distortions (equipment imports at overvalued exchange rates, artificially low and often negative real interest rates, high minimum wages), and inherent inflexibility of industrial technique choice. It is generally agreed that the resultant swelling of the urban services sector represents an increased weight of marginal, poorly remunerated activities in that sector. Even with rapid growth rates of manufacturing employment, in the near term manufacturing can make only a minor contribution to the expansion of total employment given the sector's low initial share of the labor force (*23*).

In the face of slow expansion of productive urban employment positions, policies which stimulate agricultural employment will not only tend to improve rural income distribution but will arrest the process of increasing concentration of urban income which would be associated with more rapid rural-urban migration. Furthermore, given labor force and employment prospects, it seems likely that both urban and rural income distributions will grow more skewed unless the past distortions in import substitution industrialization policies are corrected and the recent trends toward skewed channeling of benefits of agricultural modernization are reversed, through conscious selection of employment generating and income equalizing policies.[1]

Demand Elasticities for Agricultural Products

Before examining individual policies, it is important to give special attention to considerations concerning demand elasticity for agricultural goods. Developing countries experiencing the Green Revolution have poor prospects for exports of food products, partly because their neighboring potential customers are experiencing the same revolution and partly because the advanced countries may be expected to react vigorously to any increased competition (*17*, pp. 702–3). To the extent that demand must come primarily from the domestic market, two phenomena related to demand elasticity will be of great importance. First, strategies which spread benefits of increased production equitably in the countryside will be more successful in generating the demand for increased supply than will policies increasing output while displacing labor and sharply concentrating rural income, for simple reasons of income elasticity of demand for food. That is, there is a feedback from the income distributional nature of a given agricultural strategy to the demand available to absorb increased agricultural supply resulting from that strategy. Second, any measure which increases production

[1] The magnitude of the labor absorption problem has led Dudley Seers to propose a reversal in planning mechanisms: employment targets would replace income targets, and sectoral expansion plans and capital requirements would be derived from employment objectives (*34*).

other than by directly increasing inputs of labor will tend to substitute for labor and may even decrease the demand for labor in absolute terms.

The second point may be clarified by considering a model in which the price elasticity of demand is unity (i.e., optimistically high if there is only domestic demand for foodstuffs). Consider a technical change (e.g., improved seeds) that at no cost multiplies yields by the factor λ. The resulting demand for labor will by no means be λ times the initial level and may even decrease, as may be seen in the model.

$$(1) \quad Q = \sum_i \gamma_i C_i \,;\; C = \sum_i C_i$$
$$(2) \quad N = \alpha C + \beta Q$$
$$(3) \quad Q_s = bP$$
$$(4) \quad Q_d = a/P$$
$$(5) \quad P_e = (a/b)^{1/2} \,;\; Q_e = (ab)^{1/2}$$
$$(6) \quad \gamma_i^* = \lambda \gamma_i$$
$$(7) \quad Q_s^* = \lambda b(P)$$
$$(8) \quad Q_e^* = [a(\lambda b)]^{1/2} = (\lambda)^{1/2}(Q_e)$$

Production (Q) equals the sum over i qualities of soil, of yield (γ_i) times area cultivated (C_i). The use of labor (N) is proportional in part to area (C) and in part to output (Q). Supply (equation 3) is positively related to price (with unit cost rising with quantity due to incorporation of the Ricardian margin, i.e., lower and lower γ_i as more marginal land is cultivated); to simplify results, the function is assumed to pass through the origin. The demand function (equation 4) is a rectangular hyperbola, with unitary price elasticity. Equilibrium price (P_e) and quantity (Q_e) are shown in equation (5).

If all yields increase by the multiple λ (equation 6), the supply function merely moves to the right by the multiple λ (equation 7) and the new equilibrium output is not λ times original output but only $(\lambda)^{1/2}$ times original output. Equilibrium output expands by a smaller proportion than yields. Labor use expands by a smaller proportion than equilibrium output, and may actually decline. The reason is that cultivated area must decline (otherwise output would increase by the full proportion λ) and a portion of labor is tied to area cultivated rather than output. In the example with yields doubling ($\lambda = 2$), equilibrium output rises by only 41 percent; area cultivated must shrink by at least 29 percent (by the proportion $(2 - \sqrt{2})/2$ in the limiting case of equal yields across all soil types). The condition for total labor use to decline is that the share of labor proportional to area be at least 59 percent (i.e., $.29x \geqq .41(1 - x)$, where x is the fraction of total labor proportional to area rather than output).[2] This figure is within reasonable magnitudes—i.e., 60 percent or more of labor being dedicated to plowing and weeding with 40 percent or less dedicated to harvesting and threshing. In short, reasonable parameters suggest that exogenous yield increases (through improved varieties or introduction of double-cropping *via* mechanization) can

[2] More generally, the condition for the yield increase to raise rather than lower demand for labor is that the fraction of labor associated with area, x, be less than:

$$(\lambda - \sqrt{\lambda})/(\lambda - 1).$$

This fraction rises from a minimum of .5 to a maximum of 1.0 as λ rises from 1 to ∞.

actually reduce employment, in the context of demand with unitary or lower price elasticity. The demand for labor will be even lower, of course, if price elasticity of demand for agricultural goods is below unity.

The policy implication is that output-increasing technical changes should be viewed with an awareness of their potential negative impact on labor demand, and therefore should be carefully scrutinized with respect to their real capital costs. Although one may object that in certain areas of the Asian Green Revolution the demand for labor has been observed to increase along with output and yields, it is likely that in large measure this simultaneous increase is due to the restricted regional nature of the change, and ignores eventual decrease of demand for labor in the regions not experiencing the "Revolution" for lack of irrigation facilities.

The above discussion should not be interpreted as implying that low-cost yield-increasing technical change should be opposed by policy-makers. Such a rejection clearly would not be Pareto optimal, and could only be optimal in a severely constrained, second-best world with concentrated land ownership in which income could not be transferred to displaced workers and in which employment weighed heavily in the social welfare function relative to output. Furthermore, yield-increasing technical change will increase real farm income,[3] and there will be an induced expansion of demand from the income effect which will require extra employment and partially offset any labor dislocation in the unfavorable case outlined above.

Finally, the implications of the static analysis above are mitigated by the fact that in a growing economy the demand for agricultural goods is likely to grow more rapidly than the agricultural labor force, especially if the ratio of urban to rural labor is rising rapidly. Secular increase in demand for agricultural goods can therefore offset decreases in labor requirements per unit of output.

Rural Income Distribution and Savings

In the economic development literature the idea has become established that a trade-off is likely to exist between equity and long-run growth, due to assumed savings propensity differentials between employers and workers, or more generally, between the rich and the poor. In a previous study the author examined the theoretical and empirical grounds for this argument, and found the trade-off to be of limited magnitude, based on estimates from family budget studies for Argentina, Brazil, Mexico, and Venezuela, and assuming the consumption function form most damaging to savings under income equalization (*12*).

For purposes of the present study it is useful to examine the agricultural sector alone and to consider the effect of alternative strategies on savings. The problem may be specified by postulating neutral, more skewed and less skewed distributions for incremental agricultural income and calculating the resulting alternative effects on agricultural savings.

[3] Unitary price elasticity of demand would appear to constrain farm income to a constant level regardless of output level. Yet clearly real income rises when output rises. The reconciliation is that an average between the *ex ante* and *ex post* prices must be used in evaluation of output, if all output is consumed within the farm sector. If all output is sold to outsiders, then nominal income must remain constant given unitary elasticity, but decreases in food prices should translate *ceteris paribus* into lower nominal industrial wages, lower industrial prices, and therefore higher real value of farm monetary income.

Using rural family budget survey data for Brazil and Mexico, family consumption functions of the form $c = e^{\alpha} y^{\beta}$ were calculated (*19*, *2*).[4] The average savings ratio for rural income was then calculated as:

$$(9) \qquad s = \sum_{i} \lambda_i (1 - e^{\alpha} \bar{y}_i^{\beta - 1})$$

where there are i quantile groups of recipients, λ_i is the income share of group i, and $\bar{y}_i$ is the average family income for quantile group i. The following experiments were then conducted: (a) agricultural income rises by 20 percent for all families; (b) a 20 percent rise occurs in agricultural income but goes wholly to the upper 20 percent of income recipients; (c) a 20 percent rise occurs in agricultural income but goes wholly to the bottom 80 percent of income recipients. Each of these experiments generates a different vector of income shares (λ_i) and average group family incomes ($\bar{y}_i$) and therefore a different aggregate average rural savings ratio.

The results of these experiments were that the savings ratio was not especially sensitive to the distribution of the 20 percent increment in rural income.[5] The savings rates were higher for the most skewed version, but not radically so and certainly not so to the degree implicit in a conventional dichotomy of "the rich save, the poor do not."[6] Furthermore, actual attainment of the higher savings rates for the highly skewed alternative would in practice be questionable, since this alternative would face the constraint of negative demand feedback from concentrated rural income, as discussed above.

INCOME DISTRIBUTIONAL EFFECTS OF ALTERNATIVE AGRICULTURAL POLICIES

Land Redistribution[7]

Of the alternative agricultural policies, land redistribution is the most likely to attain increased equity along with increased production. However, due to political constraints it is frequently the least likely policy to be carried out.

[4] For Brazil, the result was:

$$\underset{(17.6)}{ln(c) = 2.324} + \underset{(27.3)}{.605\, ln(y)}, \quad R^2 = .96$$

with T ratio in parentheses. For Mexico it was:

$$\underset{(7.8)}{ln(c) = 2.19} + \underset{(18.6)}{.704\, ln(y)}, \quad R^2 = .98.$$

Units: Brazil, annual 1,000 cruzeiros of 1962; Mexico, monthly pesos of 1963.

[5] For Brazil, the original average savings ratio was .199. The new savings rates for the neutral, skewed, and equalizing experiments were .255, .277, and .230, respectively. For Mexico, the respective ratios were −.170, −.108, −.069, and −.137. Note that while the absolute savings rate estimates may not be valid (particularly the negative values for Mexico), the relative changes of savings as a fraction of income should be valid (*12*, ch. 4).

[6] Note that H. T. Oshima has even suggested that income equalization can tend to increase savings by raising income for poor families and reducing their dissavings. His observations are based on prewar and postwar Japanese rural savings and income distribution data, and on cross-section comparisons of savings rates and income distribution between Japan and Taiwan on the one hand and the Philippines and Ceylon on the other. The suggestion, if taken literally and imposed on constant total income in a context of static redistribution, would imply a highly unusual consumption function (marginal propensity to consume rising with income) in order for decreased savings of rich income losers to be more than offset by reduced dissaving of poor income gainers. However, the spirit of his argument is very similar to that proposed here—namely, the savings costs of increased equity have been overemphasized (*32*, pp. 172–74).

[7] This section draws heavily on the author's earlier study, *Economic Consequences of a Land Reform in Brazil* (*10*).

Nevertheless, land redistribution deserves particular attention because of its potential for joint increase in output and equity.

Theory.—Land redistribution away from large landowners toward family, cooperative, or state farms for former tenants, workers, unemployed laborers, and farmers with miniscule plots, has been cited as a policy which can increase production through the general effect of increasing incentive of the operator to use the land. The conventional emphasis is on the lack of land utilization by large traditional owners holding land primarily for prestige (most frequently cited for the Latin American case), and on the incentive distortions of tenancy due to share-cropping arrangements or lack of long-term investment horizons associated with uncertain tenancy (*36*, p. 15). Concerning income distribution, land redistribution should tend to equalize rural income over time since land is the principal factor of agricultural production; furthermore, the less compensation paid to expropriated landowners, the more immediate and radical is the redistribution of rural wealth.

The two principal issues that affect land reform's impact on production are whether economies of large-scale production exist, and whether land utilization does in fact decline as farm size (in area) rises. If there are increasing returns to scale, fragmenting large producing units will lower output, and even installing small units on formerly unused land will create a structure unable to attain efficient production. The primary reason to expect possible scale economies would be the argument that minimum areas are required to utilize certain farm machines (such as tractors and self-propelled combines). However, in a labor surplus context these machines are not likely to be profitable at appropriate capital, exchange rate, and product prices, and *a fortiori* are not likely to be socially profitable if labor is shadow-priced. Even if they are profitable, these machines can in principle be supplied on a custom service basis, so that their availability need not depend on farm size. In short, the agricultural economies of scale argument warrants little weight in the context of the developing countries.

In contrast, there are several reasons to expect land utilization to decline as farm size rises, in addition to the "prestige" and "incentive" factors already mentioned. First, there exists a "labor market dualism" between small family-labor farms and large hired-labor farms analogous to the dualism between the traditional and modern sectors in the established "surplus labor" theories. The large capitalist farms pay the institutional wage, and equate labor's marginal product to it. Small family farms utilize their available stock of labor in combination with their limited amount of land to the point where the marginal utility of product equals the marginal disutility of effort. However, this small-farm equilibrium results in a marginal product of labor below the institutional wage and therefore below the marginal product of labor on large farms. This disequilibrium between the two sectoral marginal products results in part from physical friction (i.e., the infeasibility of sending wage supplement from the family to the out-hired member) and in part from the general rigidities which prevent sectoral marginal product equalization between the "traditional" sector and the "modern" sector in the economy at large (primarily, the unwillingness to work for a wage below an institutionally accepted minimum despite the fact that to

do so could somewhat enlarge the total family income, so long as marginal product of the family-leaver fell short of any outside wage whatsoever).

Lower marginal product of labor on small family farms means greater utilization of land: for a given profile of Ricardian declining fertility of land, a larger percentage of land would be brought into cultivation on a unit prepared to accept a lower marginal product of labor working with that land. In sum, the labor market dualism consideration would predict poorer utilization of land by large capitalist farms than by small family farms.

A second explanation for declining land use by farm size is the tendency among larger owners to hold land as a portfolio asset rather than a production input, thereby obtaining prospective capital gains (or at least maintenance of real asset value) without incurring additional current expenses and risk by making outlays for labor and capital costs of production. This phenomenon seems to be particularly important in certain Latin American countries with prolonged inflationary experience. Further reasons to expect land use to decline with increasing farm size include imperfection in the land market, not only in the form of greater availability of credit to large buyers, but also the fact that, for constant quality of land, unit price is lower in large block transactions; the possible effect of oligopsony in a region dominated by a few large landlords who affect the regional wage by their activities and therefore attain a below-competitive production and land-use equilibrium; and the fact that small farms produce in part for their own consumption and are therefore less exposed to market risk than larger farms.

The one major counter-explanation of declining land-use intensity is the argument that larger farms tend to have lower quality land, in terms of fertility and location.

Empirical Evidence.—Two types of information exist for hypothesized effects of land redistribution on output and income equity: *ex ante* data on agrarian structure and *ex post* historical data for countries which have carried out redistribution. For Latin America, there is a large consensus of interpretation of the *ex ante* data, to the effect that the observed pattern of high output per total farm area on small farms, low output per total farm area on large estates, and underutilization of labor crowded onto miniscule plots or merely unemployed, suggests a substantial potential for increased production as well as increased employment through land redistribution (see, for example, *36* and *5*). Data on agrarian structure in India show a similar pattern of lower production per available area on larger farms, implying potential output gains from land redistribution (*33*).

My own empirical tests using data for approximately 1,000 farms in Brazil indicated: (1) returns to scale for inputs used are constant: the sum of factor elasticities does not differ significantly from unity, based on production function estimates; (2) land utilization (on alternative measures) declines significantly as farm size rises even when the influence of land quality is removed by inclusion in regression models of land price as a proxy for quality; (3) if present land and other input use patterns relating to farm size, and present production functions, were to prevail after land redistribution to a family farm structure, farm output would increase a predicted 20 to 25 percent under a "total redistribution,"

or 5 percent under a conservative prediction exempting intermediate size farms and farms with below average land price from redistribution; both calculations understate output gains by ruling out product shifts due to a lack of information on land quality (*10*, pp. 78, 130–31, 165).

The historical or *ex post* empirical evidence is more cloudy. The principal problem is one of separating temporary disruption phenomena from long-run structural effects. Poor data availability, particularly with regard to total production as opposed to marketed production, further complicates analysis of *ex post* cases. For the Mexican case, Dovring has indicated that revised historical data dispute earlier data showing lower production in 1925–29 than before the 1910 revolution (*16*, p. 265). In any case, declining or stagnant production could have been expetced given the uncertainty generated by lack of definition of the agrarian reform prior to the vigorous land redistribution activities of the Cardenas regime in the 1930s. Furthermore, the subsequent relative stagnation of the *ejido* sector and dynamism of the new private sector cannot be accepted as evidence against land reform's production effects. The new dynamism itself required the land reform's pressures for land utilization (for example, farm-size ceilings) as its precondition; most of the new resources of irrigated land and credit have been channeled to the private sector (*35*, p. 12); and the *ejido* sector uses labor-intensive techniques that are probably more appropriate on a shadow-price basis than the capital intensive techniques of the dynamic private sector (*16*, p. 273).

Doreen Warriner describes land reform experience in the Middle East in terms of the overriding importance of irrigation and the need for administrative structures to preserve its availability, attended to by large landlords prior to reform. Egypt, with very great land scarcity, was not characterized by unused land on large farms prior to reform; a good public administration did manage to maintain production after reform, although increases in productivity could not be attributed to land redistribution but to other measures. Iraq, with better production effect potential in view of land-use patterns, suffered worse results due to a long period of uncertainty, while Iran maintained productivity and reached a fourth of the rural population with a quick and decisive implementation of land reform (*41*).

The postwar land reform in Japan turned tenants into owners, and rapid inflation virtually eliminated the real value of their repayment burden and landlords' compensation. Subsequent agricultural growth was dynamic, but it is difficult to analyze the extent to which growth through increased use of fertilizers and new varieties would have taken place even in the absence of any incentive effects of the structural reform.[8]

While it is far beyond the scope of this discussion to reach verdicts about the historical evidence on land reform's production effect, it is justifiable to conclude that the wide diversity of historical experience shows the importance of: (1) the incidence of underutilized land prior to reform, (2) the speed and degree of certainty with which reform is implemented, and (3) the degree to which credit and modern inputs are made available to the reform's beneficiaries. Therefore,

[8] For a description of the Japanese case, see *14*.

the evidence suggests that with appropriate policy in the latter two dimensions, the expected output gains based on *ex ante* data can be realized.

A final caveat on the income distributional impact of land redistribution is required. To the extent that programs are implemented on a limited basis, with land made available to an elite minority of farmers or even former urban residents, the policy ceases to be a significant instrument for improving equity.[9]

To summarize, land redistribution is the policy instrument most likely to improve rural income distribution, both because of the resulting changed distribution of future production flows and because of the major scope for labor absorption through land reform in the context of otherwise bleak employment expansion prospects. There are theoretical and empirical grounds to expect land redistribution to raise production as well. However, this instrument is also the least likely to be adopted in the absence of major political change.

Improved Seed Varieties and Fertilizer

Because increased output from new high-yielding seed varieties approximates manna from heaven, especially if international agencies or foundations pay for the development of the varieties, no one can oppose the policy of expansion of new varieties. Since the production impact of these seeds is multiplied by fertilizer application, the package of improved seeds with fertilizer is generally accepted as economically desirable, although fertilizer in the absence of improved seeds (or of irrigation, or both) is often more costly than the value of the resulting increase in output.

The impact of improved seeds *cum* fertilizer on income distribution is frequently held to be neutral, at least potentially if not in fact. The argument is that this type of technological change is neutral with respect to farm size and can therefore benefit farmers in all income classes. In fact, however, the Green Revolution in Asia appears to have benefited primarily the larger farmers (*17*, p. 706), at least initially. Social tensions have increased in several areas where varietal breakthroughs have increased income disparity (see, for example, *28*, p. 766). The skewed impact on income is partly attributable to higher utilization of new varieties on large farms than on small, although recent studies indicate attainment of similar usage levels by all farm size groups after relatively short diffusion periods.[10] The tendency of larger farms to combine new varieties with mechanization, and their greater application of fertilizer and other complementary inputs due to greater credit availability (*25*, p. 292), have also contributed to a widening of rural income dispersion associated with new varieties. A further dimension of inequality in the varietal revolution concerns regional disparity; since the varieties require irrigation for full benefit, it is the regions with irrigation resources which benefit; the other regions lag not only relatively but stand to suffer in absolute terms as increased output in the dynamic regions depresses national agricultural prices (*17*, p. 705).

There are two further considerations which have received less attention which

[9] This practice occurred in the early days of the Chilean agrarian reform agency, as reported by M. T. Sternberg (*36*, p. 18).

[10] For results based on dwarf wheat adoption by 350 farms in a sample in Pakistan's Punjab, as well as a survey of similar studies, see *30*, pp. 133, 184–90.

also imply a skewed distributional impact of improved seed varieties and fertilizer application. First, these improvements benefit the farm owners more than landless workers, since they tend to raise profits more than proportionately to output and raise the wage bill less than proportionately. The essence of a new variety is that it multiplies yield at little or no increase in intermediate input costs; and labor costs remain unchanged to the extent that wages are constant (reasonable in a labor surplus context), and labor requirements are proportional to land area (plowing, weeding) rather than output (harvesting, threshing). In the limiting case of no increase in intermediate or labor costs in the face of a λ-fold rise in output, profits will rise by the multiple $(\lambda - 1 + \beta)/\beta$ where β is the original profit share. Thus, if yields double, and original profit share is .5, new profits will be three times their original level while the wage bill will have remained unchanged.

The second consideration concerns price elasticity of demand for agricultural goods. The lower this elasticity is, the greater is the likelihood that new seed varieties combined with complementary inputs will displace labor rather than increase demand for it, as discussed above.

These observations suggest that there is some degree of unequalizing income distributional impact inherent in the strategy of improved seeds *cum* fertilizer, and that this bias is greatly increased if credit and informational networks channel these improved inputs to the larger farms. Nevertheless, the output effects of these improvements are so dramatic that it would be highly inefficient (in a Pareto sense) to oppose them. The policy implication is that if perverse income redistribution effects of new seed varieties are to be minimized, not only must the inputs reach small farmers on an equal footing with large farmers, but there may also be a case for skewing the channels toward small farms. The differential impact on profits versus wage bill will thereby be lessened, through the placement of improved inputs on farms employing primarily family labor (and thus profit-sharing labor) rather than hired labor.

Farm Mechanization

The most controversial agricultural policy in the 1970s will probably be farm mechanization. Tractors and combine harvester-threshers are the most sensational instances of mechanization, although stationary mechanical threshers, pumpsets, reapers (drawn by tractor or bullocks), and a gamut of modest mechanical improvements for bullock traction (e.g. mouldboard plows, improved yokes), are also candidates for expansion. Before examining the implications of a mechanization strategy for rural income distribution, it is necessary to review the arguments for and against mechanization with respect to production alone.

At first glance, farm mechanization appears to be a capital intensive technique choice which is inappropriate for the labor abundant factor endowment of developing countries. However, the arguments put forth in favor of mechanization recognize that labor replacement alone is inappropriate, and are based on the contention that mechanization can raise production and even increase the demand for labor as a result. The principal arguments are: (1) tractor mechanization permits speeding up the plowing, harvesting, and threshing sufficiently

that (a) the subsequent crop may be planted at the optimal time to maximize yield, and (or) (b) double-cropping may be practiced where impossible before; (2) tractor plowing increases yields; (3) replacement of bullocks by tractors will release land presently dedicated to fodder for production of higher value crops.

Tractors substitute for labor because one worker with a tractor substitutes for several workers with several bullock teams in individual operations (such as plowing). However, some authors argue that by permitting double-cropping, tractors permit an increase in output and in year-around employment (*22*). A major caveat concerning this argument, however, is that it is not applicable to land abundant regions where the cost of irrigation and land-saving through double-cropping is unwarranted; one must immediately be alert to the fact, then, that tractor mechanization is much more likely to be purely labor-substituting than land-saving in the cases of land abundant areas such as many regions of Latin America and Africa.

Furthermore, the "timing" and "double-cropping" argument makes the assumption that the supply of bullock power is inadequate at the peak season of threshing one crop and plowing for the next. Thus, one careful study concludes that for irrigated areas in West Pakistan producing a wheat-cotton sequence, tractors are profitable even in social shadow-price terms because they permit sufficiently rapid plowing to allow planting of the cotton at the optimal time, whereas the study's calculations show tractors unprofitable socially in East Pakistan for a rice double-cropping sequence, due to the much lower sensitivity of rice yield to planting time (*28*). Yet this conclusion hinges on the crucial bullock-area ratio assumed for the wheat-cotton calculations, for it is nothing other than insufficient bullock availability per farm unit which makes the land preparation too slow to permit optimal timing.

Even if the bullock supply at peak periods were regionally a bottleneck, given the regional concentration of irrigation in India and Pakistan a logical policy would be a migration of bullocks from other areas not experiencing the Green Revolution for lack of irrigation, prior to tractor mechanization.

More fundamentally, S. R. Bose and E. H. Clark have virtually dismissed the "timing" argument on grounds that harvesting and threshing can be accelerated by the use of stationary mechanical threshers (replacing bullocks) and the use of improved implements which could greatly accelerate bullock plowing (*7*, p. 276). Their estimates of the benefit of tractor mechanization, therefore, concentrate on the gains from area released from irrigated fodder production which could be obtained by replacing bullocks. Making use of a careful and comprehensive methodology, Bose and Clark conclude that social benefits of tractor mechanization fall short of social costs, although private benefits exceed private costs (the divergence being primarily due to world price versus support price valuation of increased crop production on the freed land). However, since the study makes no shadow-price adjustment of tractor prices to account for free entry despite an overvalued exchange rate (thereby accepting lower prices per horsepower in Pakistan than in the United States), and since a low *ex ante* market price is used to evaluate animal products despite a radical reduction in the supply of these products implicit in the calculations, the results should give an upper limit estimate of the net social benefits to tractor mechanization. There-

fore, their conclusion of the lack of social profitability of tractors would be strengthened by inclusion of these important adjustments.

The evidence of a positive influence of mechanization on yields (net of any influence of double-cropping) is weak (see, for example, *26*, p. 128). To be sure, in unirrigated areas with a dry hardpan, deep plowing by tractor may increase yields, but both the yearly frequency needed and the geographical magnitudes of this need are unclear.

Estimation of the influence of mechanization on yields is usually inconclusive due to the failure to remove the influence of other inputs. In an attempt to provide information on the net yield effect of tractor mechanization, the author has estimated a regression of yield per hectare against a constant, the number of tractors per hectare, and fertilizer per hectare, for 117 rice farms in the south of Brazil.[11] The result showed a statistically significant positive effect of mechanization on yields, but the magnitude of the influence was negligible: estimation of the function for the highest observed tractor/area ratio increased yield by only 0.02 percent above the estimated value for production without tractors.

In general, the "output increasing" arguments favoring tractor mechanization need careful empirical investigation. Despite the lack of reliable verification of these arguments to date, farm mechanization has received support from government programs of less developed countries,[12] and in some instances from international lending agencies.[13] The stock of tractors has grown rapidly despite frequent *ex post* findings of poor profitability experience with tractors (*31*, p. 73).[14]

Factor price distortions account for much of the incentive to increase machinery inventories. In Brazil, farm credit has been available at negative real interest rates, with an official ceiling of 18 percent per annum in the face of price increases between 20 percent and 40 percent annually, in the late 1960s (*37*, p. 19). In the case of Pakistan, due to high wheat price supports, exemption from tariffs, and an overvalued exchange rate, tractors may be purchased at half the world tractor/product price ratio (*26*, p. 127).

To recapitulate, rapid tractor stock growth appears to be due primarily to artificially low capital prices, and passively or actively favorable public and inter-

[11] The data used for the analysis are described in *10*, p. 188. The regression equation was:

$$q = 45.83 + .068T + .0067F$$
$$\quad (18.5) \quad (2.2) \quad (1.7)$$

where $q = 50$ kg. sacks of rice per hectare cultivated, $T =$ tractors per hectare, $F =$ kg. of fertilizer per hectare: t-ratio in parentheses. $R^2 = .05$.

[12] In Brazil, recent government plans call for long-term loans to increase the tractor stock from its 1969 level of 80,000 to 120,000 by 1973 (*9*, p. 101). In West Pakistan, the government has been advised to adopt a program of rapid mechanization, according to Hiromitsu Kaneda (*26*, p. 130).

[13] The cumulative total of International Bank for Reconstruction and Development (IBRD) loans for agricultural mechanization stood at $24.4 million in 1970 (*21*, p. 110). As of 1970, the IBRD was proposing a new $25 million loan to finance tractors in India, and had several similar loans pending, according to W.P. Falcon (*17*, p. 706). The Inter-American Development Bank made loans for mechanization credit amounting to $52.2 million (excluding mechanization components of general credit loans) in the period 1961–67 (*20*, p. 16).

[14] Rice farms in Rio Grande do Sul, Brazil, provide a particularly good data source. The tractor stock on these farms increased from 5,405 in 1960 to 9,312 in 1969, giving an annual growth rate of 17 percent (*8*). In India, the number of tractors rose from 20,980 in 1955/56 to 53,966 in 1965/66, representing an annual growth rate of 9.4 percent (*39*, p. 34). Furthermore, unpublished estimates indicate that the number reached 98,000 by 1969/70, giving an annual growth rate of 15 percent in the last four years of the 1960s.

national lending agency policy, despite the high likelihood that tractors principally substitute for low opportunity cost labor and bullocks and despite the absence of reliable verification of arguments that mechanization increases output by breaking physical bottlenecks.

Turning to the impact of mechanization on income distribution, the crucial issue is clearly the extent to which farm machinery will reduce the demand for labor and thus rural employment. Unfortunately, widely varying estimates exist on the amount by which tractors or combines reduce labor requirements,[15] and the issue is further confused by the blithe assumption in several calculations that double-cropping increases with mechanization (i.e., as a requisite) so that the *ceteris paribus* substitution of machines for labor is obscured.[16] Thus, there is a great need for reliable empirical estimates of the different labor requirements by farm machine techniques to be supplemented with empirical estimates of the degree to which multiple cropping requires specific types of mechanization.

One important facet of labor displacement is that in the Asian context mechanization often means displacement of traditional tenants, with social implications perhaps more serious than those for displacement of temporary labor; indeed one nonprice incentive to mechanization may be the desire to expel tenants in view of land reform statutes which pose the potential threat of turning land over to tenants.

In addition to labor displacement, the farm size bias inherent in mechanization programs makes mechanization income concentrating. In the absence of specific policy to channel machinery through government agencies on a rental basis, the great concentration of tractors and other machines will be in the largest farms (see, for example, *6*, p. 8). Furthermore, the large increment of fixed cost of production associated with mechanization will induce large mechanized farms to continue production even in the face of drastically declining product prices (*26*, p. 133), thereby impoverishing the smaller farmers with smaller percentage rises in physical output.

The policy implications of the above discussion are the following: (1) Government or international financial institution support of mechanization is unjustified unless further empirical evidence substantiates the arguments that mechanization can increase output rather than merely substitute for labor. (2) In the event that the output-increasing effects are verified, mechanization should be channeled through rental programs available to all farm sizes, if the governments are concerned about preventing increased rural inequality. (3) Simpler, intermediate mechanical improvements for bullock technology should be encouraged, as opposed to tractor or combine mechanization.[17] (4) Scarcity prices should replace the common artificially low principal and interest prices for farm ma-

[15] To cite only one instance, Bose and Clark report that their interviews in Pakistan returned the "remarkably consistent" response that labor force per acre fell by 50 percent after mechanization, then they cite another study which indicated reduction of 83 percent (*7*, p. 285).

[16] The calculations of M. H. Billings and Arjan Singh follow this route, without taking any account of demand. Even with the compensating labor increases due to increased crop intensity assumed, however, their estimates indicate that mechanization (pumpsets, threshers, tractors, reapers) would reduce demand for labor in the Indian Punjab by 17 percent in 1983/84, compared with conventional techniques and much lower output (*6*, p. 2).

[17] One attractive aspect of this alternative is that it will require modest implements easily produced domestically, thereby avoiding balance of payments pressures and also providing backward linkage to the small-scale industrial sector. This point is emphasized in *24*, p. 577.

chinery in order to improve the chances for avoiding premature mechanization.[18]

Irrigation

Distributional effects of irrigation depend on the type of irrigation and its investment cost relative to land scarcity. Two types of irrigation may be distinguished: large government projects and widespread small-scale irrigation based on independent initiative. The latter type was remarkably successful in the case of West Pakistan's rapid tubewell expansion in the middle 1960s (*27*), and the wide dispersion of the tubewells (and the possibility for joint use of a tubewell by farms too small for sole use) suggest that this type of irrigation has income equalizing effects, at least insofar as increasing the middle income share relative to the upper income share. Where the water table does not permit easy expansion of tubewells, a variation on this type of irrigation (widespread, small-scale) is pump-sprinkler installations drawing water directly from rivers.

Large government projects with major dams and channel systems are more likely to be very costly, benefit only a small fraction of the rural population, and therefore be income concentrating. Proposed irrigation projects of this nature for the Northeast of Brazil involve a capital/labor ratio on the order of U.S. $5,500, as compared with a capital/labor ratio of approximately U.S. $650 for Brazilian agriculture at large (*11*). Clearly only a privileged minority of rural workers can benefit from projects of this nature, and the perverse income redistribution is even greater if the government channels new irrigation facilities to the larger, more capitalized farmers.[19] However, a blanket criticism of such projects is inappropriate since in some contexts (e.g., areas in India and Pakistan with great land scarcity and perhaps more favorable physical conditions, permitting cheaper investment costs for systems) such irrigation projects may be a prerequisite for expansion of the Green Revolution. Here the obvious policy implication is that the beneficiaries should be as broadly based a class as possible.

Credit

Agricultural credit is an especially malleable instrument with respect to income distributional impact. It can be channeled to rich or poor farmers (although it cannot reach landless workers directly). In the past, credit has usually benefited primarily the large farmers.[20] This result has been due in part to their greater collateral. Also, in a situation of artificially cheap credit administratively

[18] Even with machinery prices representing the scarcity of foreign exchange and with higher real interest rates, "premature mechanization" would take place unless some tax or other mechanism made the machinery even more costly, to account for the divergence between the wage and social cost of labor. However, since correction of the latter private-social divergence is probably beyond the scope of available government instruments, as a minimum the artificial biases cheapening capital can be removed.

[19] As appears to have been the case in Mexico (*16*, p. 273).

[20] S. L. Barraclough cites the instance of Chile in 1960, when only 7 percent of commercial bank credit to agriculture reached the family farm sector, although this class provided 40 percent of agricultural output (*4*, p. 910). In Mexico, the rule of nonownership of land (and thus absence of collateral) has kept *ejido* farmers from obtaining private credit, and the national *ejido* bank has only partially offset the disadvantage (*3*). In India and Pakistan the concentration of gains from new seed varieties and the inroads of mechanization bespeak a similar pattern of credit primarily reaching rich farmers.

rationed, the political power of the larger farmers wins them a disproportionate share.

The poor prospects for basic structural change in land distribution have led some advocates to propose energetic government programs channeling credit and modern inputs to small farmers (*15*, p. 239). While redistribution of credit toward poor farmers may have positive equity effects, it is definitely a second-best option where land ownership is highly skewed and large areas lie poorly utilized: in the absence of land redistribution, credit channeled to small farmers will combine modern inputs with less land than would be reached after a land redistribution, and will therefore have lower marginal product than in the case of structural reform. Furthermore, given large farmer influence, the channeling of credit toward poorer farmers will be difficult to achieve despite official objectives.

Taxation

Land taxation and rural income taxation are two instruments potentially capable of improving rural income distribution. Land taxation would increase land utilization on large estates, particularly in the Latin American context, thereby stimulating both production and employment. However, just as the rural political structure inhibits land redistribution, it emasculates any attempts at land taxation: the tax rates are low or the levies are simply not collected. Similarly, prospects for effective rural income taxation are dismal in the absence of marked changes in political structure.

Farm Extension and Rural Education

Extension and education can have positive effects on output and rural equity, but the principal question regarding these instruments is the optimal level of investment in them. For extension, this question can only be answered reliably by empirical examination of the response of farm technique to extension activities and cost-benefit analysis of these activities. Extension can be expected to have a favorable impact on distribution since the larger, more capitalized farmers are more likely already to be acquainted with improved techniques than are smaller farmers.

The benefits of rural education for output and equity seem likely to be overestimated when based on empirical analyses of returns to education, since some component of observed correlations between education and income will represent the nongermane "screening" function of educational pedigree in the allocation of limited jobs among unlimited applicants, and the *ex ante* relationship of income to education is therefore likely to be broken as educational supply increases. The point here is not that rural education cannot be expected to provide some increase in output and equity, but that empirical estimates are likely to overstate these expected effects.

Colonization

In areas of Latin America still virtually unsettled, colonization is a policy alternative with favorable production and income distribution possibilities. Un-

fortunately, the candidate regions are usually so far from major markets that colonization must be based on a subsistence or own-consumption farm pattern (*10*, Appendix A). Furthermore, infrastructure investments for transport, health, and housing facilities usually make colonization a costly option whose principal attraction is that it is politically innocuous compared with land redistribution in established areas.

Minimum Wages and Rent Controls

Minimum wages and rent controls are both policies conceived to improve rural income distribution and likely to worsen it. Agriculture is noted for its greater factor substitutability than industry, and the reaction of large farm owners to higher (or newly enforced) minimum wages is likely to be replacement of workers by machinery. With elasticity of factor substitution of unity, total farm wages would remain constant after increased minimum wages, although the number of workers obtaining jobs would decline; with substitution elasticity above unity, the total wage bill and number of workers would decline. In both cases income distribution would worsen.[21]

Rent controls are also likely to have effects opposite to those intended, although in this case the result depends on the flexibility of the landowner in responding to lower rent ceilings. The absentee owner with no intention of direct involvement in production may tolerate lower rents; the owner at the margin between direct and tenant production will replace tenants with hired workers or machinery when rent ceilings are enforced.

TRENDS IN RURAL INCOME DISTRIBUTION

B. F. Johnston and J. B. Cownie have suggested a useful distinction between a bimodal agricultural strategy and a more equitable strategy (*24*). The former relies on a subsector of medium and large capitalistic farms for its output growth while consigning the bulk of agricultural labor to a stagnant enclave; the dynamic subsector is mechanized, irrigated, and provided with modern seed and fertilizer inputs. Mexico is their example of this strategy. The more equitable alternative strategy envisions widespread adoption of improved seeds and fertilizer, avoidance of labor-saving mechanization, and in principle an equitable land distribution. Japan is the paradigm for this alternative.

The countries of primary reference in the preceding sections fit the bimodal growth classification. One should therefore find that they have skewed rural income distributions which are remaining concentrated or becoming more unequal. Unfortunately, time series data on income distribution from comparable and reliable sources are virtually nonexistent for Brazil, India, Mexico, and Pakistan. Estimates for individual recent years show highly concentrated rural distributions for these countries.[22]

[21] That is, the income disparity between employed and unemployed workers increases. Note, however, that the disparity between owners and those remaining employed may decrease as wages rise. This effect is unambiguous if the elasticity of substitution is unity or lower: total wage bill remains constant or rises while output declines (assuming fixed capital stock). However, this "improvement" in worker vs. owner distribution is not Pareto optimal since it incurs reduction in output.

[22] The best available data sources indicate gini coefficients of .448 for Brazil in 1960 and .462 for Mexico in 1963, for rural income (*12*, Chap. 3). The gini coefficient for rural consumption in India (less skewed than income, for which data are unavailable) is estimated as .293 in 1967 by A. Vaidyanathan (*40*, p. 33). Rural income distribution estimates for Pakistan are not available.

When results of the 1970 demographic census of Brazil become available there should be a sound basis for tracing rural distribution changes during the decade of the 1960s. In lieu of this information there is no reason to expect the high level of inequality in 1960 to have declined. For Mexico, the consensus is that income has grown more concentrated in the past two decades, although conclusive evidence of this trend would be difficult to muster.[23] In India, the sense of qualified observers is that the Green Revolution has benefited primarily the upper income farmers and dangerously concentrated income (*28*). Actual sample survey data for India are inconclusive on the trend.[24] In Pakistan the concentrated distribution of improved seed utilization and expansion of mechanization should have increased rural inequality in the 1960s, both among persons and between East and West Pakistan. No comprehensive data are available to substantiate this probability, however.

CONCLUSIONS AND POLICY IMPLICATIONS

The principal conclusions of this study are the following: (1) In the absence of specific policy measures to improve rural income distribution, it will tend to remain skewed or to grow more concentrated, due to labor force expansion in the face of improved seed-output gains concentrated on large farms and farm mechanization stimulated by artificially low capital prices. (2) Land redistribution is the policy most likely to bring both production gains and improved equity. Empirical studies indicate that potential output and employment increases through land redistribution are particularly large in Latin America. (3) Although varietal improvements are highly desirable, they may have a negative income distributional impact in the face of unitary or lower price elasticity of demand. (4) Farm mechanization with tractors or combines should be avoided except where it can be demonstrated that mechanization will raise output rather than merely replace labor; the available evidence suggests these instances will be rare. Estimates for rice in southern Brazil indicate negligible net effects of mechanization on yield per hectare. Even where output would be increased by mechanization by the breaking of timing bottlenecks, allowing increased cropping intensity, the extra output evaluated at social prices would have to be sufficient to exceed investment evaluated with high capital and foreign exchange shadow-prices, to justify a mechanization program. Efforts should be made to achieve improvements in implements used in bullock technology. (5) Experiments with rural family budget data for Brazil and Mexico suggest that the channeling of output gains to the low income rural families would not involve major sacrifice of potential savings.

The principal policy implications are that governments truly seeking rural equity should look to land redistribution as a principal means to this end; they

[23] See *35*, p. 25. However, this general view refers to total income rather than rural income alone.

[24] Thus, the raw data from the National Sample Survey shows slightly declining concentration of rural consumption over time (from a gini coefficient of .323 in 1960/61 to .293 in 1967/68). Corrections of the raw data for differential price movements by income class yielded little difference in this gradual equalizing trend, according to Vaidyanathan (*40*, pp. 33–36). V. M. Dandekar and Nilakantha Rath use the same raw data but different price correction methods and arrive at the opposite conclusion: real rural consumption equality decreased in the period (*13*, p. 39). It should be noted that the period 1967/68 was probably too early to register the income concentrating effects of the Green Revolution.

should terminate current price distortions favoring mechanization; they should make farm machines available to small farmers on a custom service basis when and if mechanization is found economically desirable at social prices; they should increase levels and enforcement of land and rural income taxation; and channel credit toward the poorer farmers. The policy implications for external lending agencies are: (1) leverage should be exercised to induce income equalizing policies that would otherwise be rejected due to political structures in recipient countries; (2) past flirtations with loans for agricultural mechanization should be discontinued until strong evidence on its economic desirability is found; and (3) sample surveys examining agricultural techniques, and surveys permitting the development of reliable data on income distribution, deserve special attention for financing.

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