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Faculty Working Papers

College of Business Administration

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THE USE OF ECONOMIC MODELS IN EVALUATING THE IMPACT OF RURAL DEVELOPMENT AND INCOME REDISTRIBUTION PROGRAMS IN THE LDC'S

Working Paper #38

by

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May 1975

This paper was prepared for the Agency for International Development, Office of Agriculture. All views, interpretations, recommendations, and conclusions expressed in this paper are those of the author and not necessarily those of Oklahoma State University or the Agency for International Development.

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THE USE OF ECONOMIC MODELS IN EVALUATING THE IMPACT OF RURAL DEVELOPMENT AND INCOME REDISTRIBUTION PROGRAMS IN THE LDC'S

Introduction

At the present time, there is a great deal of interest in improving the distribution of income in LDCs. This is due to the realization that the industrialization and import substitution policies of the past, while leading to reasonable rates of growth, have not led to the improvement of the lives of the majority of citizens in these countries. This is particularly true for Latin America [Thiesenhusen, 1968]. It has been argued that, at least in the beginning stages of growth, an unequal disgribution of income may be a necessary price to pay in order to achieve a high rate of growth. In other words, it has been assumed in much of the development literature that there is a trade-off between economic growth and equity in the distribution of income [Baster, 1970; Land and Soligo, 1971]. The rationale for this argument lies in the assumption that savings are scarce and that the marginal propensity to save increases as income increases; therefore, a redistribution of income will decrease the total volume of savings available for investment and, therefore, act as a limiting factor in growth. Recent empirical studies, such as that done by Cline [1972], have tended to support this argument. In a more recent effort, Applegate and Fletcher [1975] looked at both the effects of a redistribution of income within economic sectors and between sectors (i.e., between the traditional agricultural sector and the rest of the economy). The effect on GDP of a redistribution of income within sectors was measured as negligable, while the effect of a redistribution between the traditional agricultural sector and the rest of the economy was substantial but depended upon the relative levels of technology between traditional agriculture and the rest of the economy. In other words, the trade-off in terms of reduced income in the rest of the economy of increasing income in the traditional agricultural sector gets smaller as productivity increases in the traditional agriculture sector.

Recent empirical efforts have been directed to the effects of redistribution of income, primarily on the composition of demand as well as the total volume of demand [Soligo, 1974]. The effect of redistribution of income on the composition of demand is important because changes in the composition of demand changes aggregate factor intensities employed to satisfy that demand. Changes in factor intensities have an effect on employment and, consequently,

the distribution of income. It is hypothesized that the consumption bundle of higher income people is more capital intensive than the consumption bundle of lower income people [Land and Soligo, 1971]. If this is the case, then a redistribution of income in favor of the poor would lower the capital requirement of aggregate demand and, therefore, the savings effect would be partially or totally mitigated.

The studies referred to above consider the effects of changes in the distribution of income. What may be even more important is the determinants of the distribution of income. In many LDCs, the inequality of the distribution of income can be largely explained by the existence of economic and cultural dualism [Adelman and Morris, 1971]. To the extent that the traditional sector consists of traditional agriculture, rural development will improve the overall distribution of income. Therefore, rural development and the distribution of income are closely related. The purpose of this study is to synthesize some important trends of thought in the development literature that have a bearing on the distribution of income and/or on rural development. More specifically, we will examine the use of economic models and other quantitative tools in evaluating the impact of rural development and income redistribution programs. In Part I, we discuss theoretical two-sector dualism models such as those developed by Lewis, Fei-Ranis, Jorgenson and finally Mellor. These models will be discussed with respect to their implications for improving the distribution of income between agriculture and nonagricultural sectors and the implications for agricultural development policy. In Part II, the use of quantitative techniques to measure the effects of changes in the size distribution of income is examined. The total effects as reflected by the savings and demand effects as well as the effects on relative factor intensities due to changes in the composition of demand are discussed. In Part III, some recent attempts to measure the effects of certain kinds of rural programs, such as credit and technical assistance, or attempts to employ different kinds of technologies will be discussed. In Part IV, a dynamic multi-sectoral model of Guatemala is presented which is used to measure (a) the effects of allowing technological change in the traditional agricultural sector, and (b) the effects of a proposed land reform.

PART I: TWO-SECTOR MODELS OF ECONOMIC DUALISM

Models Assuming "Unlimited Supplies of Labor"

Models, which assume that labor can be supplied to the industrial sector at a constant wage rate due to surplus labor in the agricultural sector, essentially began with W. Arthur Lewis [1954] and were elegantly formalized by Ranis and Fei [1961]. Lewis felt that it was fairly obvious that in many underdeveloped countries there was a certain amount of disguised unemployment that could be

absorbed in the industrialization process. In other words, industrialization could take place with labor supplied at a constant wage rate and also output in the agricultural sector would not fall. Since Fei and Ranis elaborated on Lewis' work, we will only look at their model in any great detail.

Like Rostow and others who saw the development process taking place in stages, Fei and Ranis also envisaged three phases in which a developing economy would pass on its way to maturity. This first phase is characterized by redundant labor in the agricultural sector.

In other words, the marginal productivity of labor is zero in agriculture during this stage. This, of course, implies that labor could be removed from the agricultural sector at no sacrifice in agricultural output. It is assumed that an institutionally determined wage would prevail, which is equal to average productivity in the beginning of the phase. In other words, total product is assumed to be divided equally among the agricultural labor force. This doesn't seem to be an unreasonable assumption in the context of traditional agriculture which depends primarily on family labor. In a family, everyone will get a share regardless of marginal productivity. Phase II is characterized by Fei and Ranis as the "take-off stage." In this phase, the same institutional wage is assumed to prevail and the marginal productivity of labor is assumed to be positive but less than the institutional wage. The implication here is that removal of agricultural labor will reduce agricultural output. Phase III is reached when agriculture has been fully comercialized, i.e., labor is now paid a wage equal to its marginal productivity. These phases have important implications with respect to the supply curve of labor to the industrial sector. During Phase I, labor is redundant in agriculture so that there will be a perfectly elastic supply of labor to the industrial sector.

Since the wage rate in agriculture is assumed constant during both Phase I and Phase II, a surplus is generated in agriculture which is used to feed the industrial labor force. The agricultural surplus per industrial worker is equal to the institutional wage prevailing in agriculture. Therefore, as Lewis puts it, it is as if the workers carried this surplus with them when they leave the agricultural sector. During Phase II, the supply curve of labor to the industrial sector is upward sloping. This is due to the fact that now, as labor leaves agriculture, agricultural output will fall. The agricultural surplus per industrial worker now begins to decline. This implies that the terms of trade will turn in favor of agriculture so that the wage rate in terms of industrial goods in the industrial sector will have to increase in order to induce workers to leave the agricultural sector. In Phase III, the upward-sloping supply curve of labor is given further emphasis because now agriculture is fully commercialized so that labor is paid its marginal product. Therefore, the industrial sector now has to compete for labor with the agricultural sector according to a neoclassical economy. Fei and Ranis call the beginning of Phase II, when the supply curve of labor begins to slope upward, the shortage point.

The beginning of Phase III is called the turning point or commercialization point.

According to this model, the process of development would go something like the following:

1. Investment in the industrial sector will increase the marginal productivity of labor in industry and, therefore, increases the demand for labor.

2. As long as the economy is in Phase I, labor will be supplied to the industrial sector at a constant wage.

3. As soon as the shortage point is reached, the terms of trade will turn in favor of agriculture and the industrial wage rate will have to be increased in order to get additional labor. This will have a dampening effect on employment and the process will slow down.

4. If there is technological change in agriculture, the terms of trade need not change during Phase II. Although output in agriculture will tend to fall as a result of workers leaving the sector, this can be made up by making the remaining workers more productive. As a result, the agricultural surplus per industrial worker will rise, which will tend to turn the terms of trade against agriculture so that the supply curve of labor to the industrial section will rotate counterclockwise.

5. This now brings us to the concept of balanced growth derived by Fei and Ranis. In order for balanced growth to occur during Phases I and II, two criteria have to be met. The first criterion is the output criterion, which requires the provision of mutual market outlets for the products produced by the two sectors. This criterion requires that the terms of trade between the two sectors should not deteriorate substantially against either sector. The second criterion is the input criterion, which requires that the investment fund must be allocated such as to enable the industrial sector to demand, at the constant wage rate, the precise number of workers released as a result of investment in the agricultural sector.

6. In summary, the engine of growth in this model is investment in the industrial sector, which increases the industrial capital stock, and investment in the agricultural sector, which increases agricultural productivity.

Land is assumed fixed and labor is abundant, so the binding constraint on growth is capital or lack of increases in productivity.

Unless there is continuing investment in the industrial sector, the demand for labor will cease to grow. Given a high rate of growth of the population in agricultural sector, lack of employment opportunities is nonagriculture will imply serious deterioration in the standard of living in the agricultural sector. However, unless there is an increase in agricultural productivity, there will become a shortage of food to feed the industrial labor force and the terms of trade will turn in favor of agriculture. The conclusion of the model is that there must be a balance in the allocation of investment fund between the two sectors. Implications for Agricultural Policy and Rural Development are:

1. To Jorgenson [1964], the assumption of a redundant portion of the agricultural labor force implies that the role of agriculture in this model is merely to provide a physical location for the "industrial reserve army" which provides labor to the industrial sector. This characterization is probably accurate with respect to Phase I. It will be recalled that Phase I is characterized by zero marginal productivity of labor so that removal of the redundant portion of the labor force will not affect agricultural output or the terms of trade. Clearly the engine of growth in the economy during this phase is industrial growth or investment in industrial capital which creates employment opportunities in the nonagricultural sector. In other words, investment in industry allows the economy to move to the production possibility frontier with full employment of resources. It was assumed that up to 25 percent of the agricultural labor force in many underdeveloped countries was redundant. This would seem to imply that the correct policy for a considerable length of time (the duration of Phase I or as long as redundant labor existed) is industrialization. This policy could be carried out without any investment in agriculture.

2. In this model, the role of agriculture is to provide an agricultural surplus which could be used to feed the industrial labor force. It is assumed that the agricultural real wage will remain constant during Phases I and II. This implies that as workers leave the agricultural sector a surplus will be generated. Of course, this implies that the living standard of those who are left behind in the agricultural sector would not improve. The big concern with respect to this model is not that of increasing the standard living of the rural farmers, but how to extract the surplus and transfer it to the urban sector to feed the urban labor force. An improvement in the standard of living for the agricultural sector would have to wait until Phase III has been reached, or the commercialization of agricultural marked by a neoclassical world where wages are equal to marginal productivity.

3. Another implication of the model with respect to the distribution of income is a result of the assumption that all labor income is consumed and that all saving comes from industrial profits. This means that a redistribution of income in favor of labor or traditional farmers who do not save would decrease the total investment fund which would sacrifice growth. Therefore, built into the model is a trade-off between growth and equity.

The Jorgenson Version of the Two-Sector Model of Dualism

Jorgenson [1964] dropped the assumption of zero marginal productivity of labor in agriculture. This is consistent with the overwhelming lack of evidence to support the hypothesis of a redundant portion of the agricultural labor force. Jorgenson is able to build two phases of development into his model by making an important assumption with respect to the growth rate of the population. He assumes that, at very low levels of income, the rate of growth of the population is a positive function of per capita output of food, so that at low levels of income, increases in per capita income lower the mortality rate and increase the net rate of growth of population. There is some minimum critical level of income where the mortality rate reaches a minimum and beyond which the rate of growth is growing at a constant given rate. This property of population growth permits the possibility of a low-level equilibrium trap when per capita incomes will be constant at a very low level. Any increase in income will result in a proportionate increase in the population. However, if the rate of growth of technological change is sufficiently high relative to the constant rate of growth of population which would be attained at levels of per capita income higher than the critical level mentioned above, then the low level trap will never be reached and per capita income will continue to rise as long as technical progress takes place. In this model, the necessary and sufficient condition for sustained growth is a positive and growing agricultural surplus. This condition is met if $\alpha - \beta\varepsilon > 0$, where α is the rate of technical progress in agriculture, β is the elasticity of output with respect to land in the agricultural sector, and ε is the maximum rate of growth of the population. α and ε can be treated as policy parameters.

Implications with respect to agricultural policy and rural development are:

1. The most obvious implication with respect to agricultural policy is the importance of the behavior of population growth. The higher the critical level of per capita income before the rate of growth of the population reaches its maximum, the more likely will the economy fall in a lower level stationary state or equilibrium "trap."

2. In contrast to the Fei-Ranis model, technological change in agriculture is essential for sustained growth and the avoidance of the low-level trap. The implication with respect to policy is that there is no phase of development where agriculture can be neglected in favor of all-out industrialization.

3. The implication of the model with respect to income distribution is not clear, except that per capita income rises in both sectors. However, like Fei and Ranis, Jorgenson assumes that savings are equal to industrial profits. The implication is clear that a redistribution of incomes at the expense of capital in the industrial sector will slow down the rate of growth.

The Mellor-Lele Model

The models that have been discussed thus far have the common characteristic of assuming that capital is the binding factor of production. Labor is assumed to be abundant and employment in the nonagricultural sector will grow only as long as investment in the nonagricultural sector takes place. Mellor and Lele [1971] introduce the possibility that the binding constraint on growth is food grain production. Their thesis is that in many LDCs labor may be abundant in numbers, and even if the capital is available, employment may be constrained by lack of wage goods, primarily food grain. More specifically: "In a low-income economy, aggregate food production is generally highly inelastic to changing terms of trade between agriculture and industry, whereas the marginal propensity of the laboring class to consume food is high. Because of these two factors, the food supply available to the nonagricultural sector constitutes a major constraint on growth of nonagricultural employment in the case of a stagnant agriculture.

Mellor and Lele present a model which allows emphasis on the food-transfer mechanism, which is ignored in the dualism models of Lewis, Fei-Ranis, and Jorgenson. The model has two major distinguishing features. First, the food and labor markets are treated separately rather than assuming the labor is mobilized with increases in food production. The interaction between the food market and labor market is examined. Second, they explicitly allow for a changing share of agricultural output between the labor and landowning classes. The effect of changing relative shares on market supplies of food and hence on the rate of growth of unemployment is also examined. The more important assumptions of the model will now be presented after which the logical implications of the model are discussed.

To begin with, agricultural output is a function of only labor, land, and technological change. Per capita agricultural output can

only be increased by introducing technological change. Technological change in agriculture is often highly biased among the factors of production and varies greatly in the extent of the bias. A crucial assumption in the model is that owners of different factors of production have sharply differing consumption functions. It is assumed that there are two classes in the agricultural sector, laborers and landowners. Laborers are assumed to have a positive income elasticity of demand for food of less than one, while landowners are assumed to consume a fixed amount of agricultural output per capita regardless of its price or their income. Since landowners do not increase their per capita consumption with increases in agricultural output, the share of incremental output going to landowners will be marketed and traded for commodities produced in the nonagricultural sector. Production in the nonagricultural sector is assumed to be a function of labor and capital. In order to emphasize the role of domestic agriculture in economic development, it is assumed that the economy is closed, which precludes the importation of food grain which would relax this constraint without any attention to domestic agriculture. In this case, the economy could concentrate on industrial production and trade these goods for food grain needed to feed the urban labor force. In the nonagricultural sector, the demand for agricultural output is assumed to be a function of the terms of trade between agriculture and industry and the income of the nonagricultural labor force. It is further assumed that the consumption behavior of agricultural labors and nonagricultural labors is identical, which implies that nonagricultural laborers consume all of their income as does the agricultural labor force. Therefore, as in previous models of dualistic development, Mellor and Lele make the assumption that all labor income is consumed and that saving is equal to profits in the industrial sector. While the above discussion does not cover all of the assumptions implied by the structure of the model, it is hoped that the "flavor" of the model and approach is conveyed without duplicating the entire paper.

Equilibrium in the food market requires that marketable surplus be equal to the market demand for food. Market demand for food is equal to the budget share allocated to food consumption out of wage income by nonagricultural workers. This equilibrium condition provides the link between nonagricultural employment and marketable surplus. Since marketable surplus is equal to agricultural production less the constant amount consumed by the landowners and consumption of food by agricultural labors, the equilibrium condition in the food market provides the link between relative factor shares in agriculture and marketable surplus and, therefore, nonagricultural employment.

Equilibrium in the labor market requires that demand price of labor in the nonagricultural sector in terms of nonagricultural goods is equal to the demand price of labor in the nonagricultural sector in terms of nonagricultural goods. The supply price of labor is equal to per capita income of agricultural laborers expressed in terms of nonagricultural goods, so that labor migrates

from agriculture to the nonagricultural sector until the wage rate in the nonagricultural sector is equal to per capita income in the agricultural sector.

Utilizing the equilibrium conditions and interpreting them in a dynamic context results in the following implications and conclusions which have because on agricultural development policy and the compatibility of economic growth and equity in the distribution of income.

1. The growth rate of nonagricultural employment is positive if the rate of growth of agricultural output is greater than the rate of growth of the total labor force, and the greater the rate of growth of agricultural output, the greater will be the rate of growth of nonagricultural employment. The importance of technological change in agriculture in overall development is clear.

2. A second important implication of the analysis is that the rate of growth of employment is inversely related to the movement of labor's share in agricultural output. This follows from the fact that consumption of agricultural output by landowners is fixed and the consumption of agricultural output by agricultural labor increases as their income increases. The greater the consumption of agricultural output by the agricultural labor force, the smaller will be the marketable surplus. The smaller the marketable surplus, the less employment will be allowed in nonagriculture.

3. A third important implication of the analysis is that the larger the share of profits in nonagricultural output, the greater will be the rate of growth of employment in that sector.

Given the above implications of the model, we can come to the following policy conclusions.

1. To the extent that technological change in the agricultural sector is accompanied by increased labor's share in output, it would provide a dampening effect on the growth of nonagricultural employment. What we have here is a trade-off between long-run and short-run equity. The assumption of Mellor and Lele is that total economic development which includes significant improvements in the distribution of income, will not be achieved without substantial increases in nonagricultural employment. However, there will not be substantial increases in nonagricultural employment unless there is an increase in the marketable surplus of food grains. If the policy planners opt for policies

which will improve the distribution of income in the rural sector, there may be a short-run improvement in the distribution of income at the expense of nonagricultural employment which is the real way to a long-run solution to the equity problem.

2. Mellor and Lele do not ignore the fact that while employment in the nonagricultural sector can be constrained by lack of a marketable surplus of food grains. Once this constraint is relaxed, employment will increase only if there is also investment in the nonagricultural sector. To the extent that laborers save less than owners of capital, a short-run improvement in the distribution of income will be at the expense of investment and employment and, therefore, long-run equity. Again, we get a trade-off between short- and long-run equity. Perhaps a point should be made explicitly here, that short-run equity means just that. If there is not growth in nonagricultural employment through increased investment in industry and made possible by increasing the marketable surplus, then population pressures will negate any short-run gains which have been made in improving the distribution of income.

3. In short, what Mellor and Lele are arguing is that the apparent surplus or abundance of labor in many underdeveloped countries cannot necessarily be taken for granted. The immediate constraint on growth on the economy may be the shortage of a marketable surplus of food grains. (This is even more relevant now, because it is becoming clear that this problem may no longer be eliminated by importing food grains from abroad.) Industrialization at the expense of the agricultural sector is clearly not the answer to the development problem, nor is all-out emphasis on agricultural output. All that may result from the latter is the turning of the terms of trade against agriculture. Even if export markets could be found abroad, it is doubtful that the world market would be large enough to accomodate all LDCs following this strategy for any length of time. Ignoring this, given the rate of growth of population, it is doubtful that with a fixed land supply, employment in agriculture could keep up with the rate of growth in the population. Unless there is increased demand for labor in industry, unemployment would increase and the distribution of incomes would worsen. Therefore, what we come to, is a recommendation for a balanced-growth strategy which emphasizes both growth of agricultural output through technological change and investment in the nonagricultural sector.

4. Finally, while it appears that growth and equity are competitive, growth and equity in the long run are clearly highly compatible and probably necessary from the standpoint of providing markets for both agricultural and nonagricultural output.

PART II: EFFECTS OF CHANGES IN THE SIZE DISTRIBUTION OF INCOME

Savings and Demand Effects

One aspect of the distribution of income which has received a great deal of attention is the effect that a redistribution of income would have upon savings and consumption demand. Earlier studies, such as that done by Cline [1972], focused on the "saving effect" of a redistribution of income. Since it was assumed that the marginal propensity to consume declined as income increased, a redistribution of income would result in an overall lower saving rate. If one assumes that the economy is always operating at full capacity, then a decline in the saving rate would reduce the long-run equilibrium growth rate. This approach, which concentrates on the "saving effect," presupposes that, at best, redistribution of income will have no effect on the rate of growth, and at worst, will have a serious negative effect on the long-run equilibrium rate of growth.

Cline's basic approach was to estimate the overall consumption function and apply a counterfactual income distribution to simulate the change in total savings and, therefore, the overall saving rate resulting from a redistribution of income. Twelve income brackets are assumed, so that the marginal propensity to consume can be different for each income bracket. The average family income for each bracket is calculated as:[1]

$$\bar{y}_j = y\left(\frac{\lambda_j}{w_j}\right),$$

where: λ_j = fraction of total disposable income going to the j<u>th</u> income bracket,

w_j = fraction of total population of families in the j<u>th</u> income bracket, and

$\bar{y}$ = total family income.

The level of consumption for each income level is given by either

$$\bar{c}_j = a + b\bar{y}_j + c\bar{y}_j^{\,2}$$

or

$$\bar{c}_j = e^a \bar{y}_j^{\,b}.$$

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[1]The following notation is Cline's.

Both of the above consumption functions allow for declining marginal propensity to consume. The average per family propensity to consume for income bracket j is given by

$$\bar{s}_j = 1 - (\bar{c}_j/\bar{y}_j).$$

The overall saving rate will be the weighted sum of the average saving rates for all of the income brackets. The weights are the proportion of total disposable income accounted for by each income bracket, λ_j. Therefore, total saving is given by

$$\bar{s}_T = \sum_j \bar{s}_j.$$

A change in the distribution of income can be simulated by assuming that w_j, the fraction of families in income bracket j, remains constant, while the vector, λ, is changed. Cline assumed two counterfactual distributions, and applied these to four Latin American countries: Argentina, Brazil, Mexico, and Venezuela. The first counterfactual distribution was that of England, and the other assumed "that enough income is taken from the upper brackets to ensure a minimum income of one-half the total average family income to all lower brackets."

If we assume a constant incremental capital-output ratio, γ, and full capacity, the effects of a redistribution of income on growth can be measured using the familiar Harrod-Domar long-run equilibrium growth condition:

$$\Delta g = \frac{\Delta s}{\gamma}.$$

When Δg is the change in the growth rate, Δs is the change in the overall saving rate, calculated by comparing the original saving rate with the simulated saving rate.

The English distribution of income implies a more drastic change than the second counterfactual distribution, so that the effects on growth are greater for the former counterfactual. The results showed that the sacrifice in the rate of growth, due to a redistribution of income toward the level of equality with England, would cause decreases in the growth rate of the order of 1 percent in Brazil and Mexico, and smaller decreases in Argentina and Venezuela. The sacrifice is less for the less drastic redistribution implied by the second counterfactual.

Cline also looks at the effects of a redistribution on the composition of consumption demand as well as total consumption demand. A priori it might be expected that a redistribution of income in favor of lower income people would have a significant effect upon the import content of consumption demand. It is hypothesized that higher income people consume more imported goods or

goods with higher import content than lower income people, so that a redistribution of income in favor of the poor would increase total domestic demand and stimulate growth of the domestic market. Cline was able to get data only for Brazil and Mexico and, as a result of subsequent simulations, concluded that changing the distribution of income would have a very minor effect on imports and "income redistribution could not be expected to help growth substantially through reduction of the import bill."

The approach, such as the one by Cline, looks at the effect of a redistribution of income on total aggregate demand and savings, and the consequent effect on growth. A more disaggregated approach has recently been used, which considers the effect of a redistribution of income on the composition of demand and, therefore, the composition of output. Land and Soligo [1972] suggested that there may not be a trade-off between a more equal distribution of income and growth, because, although a redistribution of income may result in decreased savings, the capital requirements for growth may also be reduced. Several studies have been done examining this proposition. The results of these studies were reviewed in a more recent paper [Land and Soligo, 1974]. The purpose of this section is to summarize these tentative findings. The assumption is that income classes differ in their consumption bundles and that the different consumption bundles have different capital requirements. The hypothesis is that the consumption bundle for lower income groups have lower capital output ratios than does the consumption bundle of higher income groups. The studies reviewed by Land and Soligo were applied to Pakistan, Colombia, Brazil, and Turkey. The results of this review indicate the following findings:

1. A four country sample, consisting of Taiwan, Colombia, Brazil, and Pakistan, show considerable differences in the capital-output ratio among sectors of the same country and among the same sector of different countries. The authors suggest that the wide differences in the capital-output ratio for the same sectors among countries, aside from statistical error and differences in measurement among countries which may be considerable, can be attributed to three factors: (1) differences in commodity composition of output in the highly aggregated sectors; (2) differences over countries in importance of imported goods as intermediate inputs for each production sector; and (3) differences in technology and vintage of capital stock among the countries.

2. The consumption bundle of the poor in each country appears to require less capital than the consumption bundle of the rich.

3. The direct importance of manufactured goods is relatively small, and the data do not indicate that the capital requirements for a bundle of manufactured goods

consumed by the poor is smaller than for the rich. The authors are quick to point out that data in the manufacturing sectors is highly aggregated and using more disaggregated data may reverse these results.

4. Services, taken as a whole, do not appear to differ greatly in their capital intensity over income class.

5. Simulation experiments carried out in the studies indicate that a redistribution of income would have "relatively small consequences on capital requirements."

6. The simulation studies also indicate that a redistribution of income would have little effect on the growth rate of the economy or the incomes of the poor. Therefore, there does not appear to be a considerable tradeoff between growth and equity.

Land and Soligo conclude by suggesting that there are data and conceptual problems which may be important enough to turn around the results reported above. Therefore, we are left with the original hypothesis; that a redistribution of income will reduce capital requirements which can neither be accepted or rejected.

A Generalized Consistency Model

A generalized consistency model attempts to ensure the consistency of a model at different levels of aggregation. The consistency approach basically consists of an aggregate macro-economic model which is used to generate projections of final aggregate demand. Final aggregate demand is then broken down into sectoral components which make up the final demand vector in an input-output model. Given the final demand vector, sectoral gross output is then calculated using the input-output model. Sectoral gross output is then translated into sectoral value added. Sectoral employment is then usually calculated, assuming a proportional relationship between sectoral employment and sectoral value added. Several consistency checks can be made at this point.

The simplest consistency check is to see if the sum of sectoral value added is equal to national income, calculated using the aggregate macro-model. If there is a difference, then projected national income has to be changed. This changes the final demand vector, and the model is worked through to a solution again. The process can be repeated until there is agreement on both levels of aggregation.

A more sophisticated consistency check is to see if the distribution of income, implied by sectoral output and employment of the factors of production derived from the input-output model, is con-

sistent with the distribution of income which resulted in the final demand vector. This consistency check requires a much more detailed model which incorporates the distribution of income.

A "generalized consistency model" for the Philippines was recently developed [Ng, 1974]. This model is a multisectoral general equilibrium model which has the interesting feature of reconciling a constant coefficient input-output matrix with sectoral Cobb-Douglas production functions of the form

$$x_j = a_j e^{\sigma_j t} \prod_i x_{ij}^{d_{ij}} \prod_k \ell_{kj}^{\beta_{kj}} cap_j^{\gamma_j},$$

where: x_j = gross output from sector j in constant prices,

x_{ij} = input from sector i to sector j in constant prices,

ℓ_{kj} = employment of occupation level k in sector j in number of people,

cap_j = capital stock in sector j in constant prices, and

σ_j = rate of Hicks neutral technical progress.

This is done by making use of the fact that a Cobb-Douglas production function allows substitution among the inputs in volume or real terms, while the ratio between inputs or inputs and output is constant in value terms or current prices. Therefore, if the variables in the input-output model are expressed in terms of current prices, and the production functions are expressed in real terms, then a constant coefficient Leontief input-output model can be combined with Cobb-Douglas production functions, which act as capacity constraints. The incorporation of real and nominal variables enable prices to be determined endogenously. Because many sections of the model are nonlinear, it is necessary to solve the model by interation using the following steps:

Step One. Step One consists of calculating gross sectoral output given the vector of final demand. This is accomplished by using the following equation:

$$X = [I - \alpha(I - \tau)]^{-1} F,$$

where: X is an nx1 vector of sectoral gross outputs,

F is an nx1 final demand vector,

I is an nxn identity matrix,

α is an nxn matrix of input-output elasticities, α_{ij}, and

τ is an nxn diagonal matrix whose diagonal elements are the indirect tax rate for sector j.

If we define

$$X_i = P_i \; x_i, \text{ and}$$

$$X_{ij} = P_i \; x_{ij},$$

then constancy of factor shares implied by the Cobb-Douglas production function implies that $\frac{X_{ij}}{X_j}$ is constant. The form of the production function, therefore, implies that $\frac{X_{ij}}{X_j} = \alpha_{ij}(1-\tau_j)$, where α_{ij} is the elasticity of output j with respect to input i, or the gross factor share (before indirect taxes). Similarly,

$$\frac{W_{kj}}{X_j} = \beta_{kj}(1-\tau_j), \tag{2}$$

where W_{kj} is the total wage bill paid to the k<u>th</u> occupation in sector j, and

$$\frac{GRC_j}{X_j} = \gamma_j(1-\tau_j), \tag{3}$$

where: GRC_j is the gross return to capital in sector j. Therefore, once X_j is calculated, it is then possible to calculate the returns to the factors of production.

<u>Step Two</u>. Step Two consists of calculating the wage rate and employment by occuption and sector. The labor market is an interesting feature of the model. Perfect intermediate-input markets are assumed, but no such assumption is made for labor markets. It is assumed that the wage rate for the same occupation is distorted by a constant factor for each sector. Therefore, the wage rate for occupation k in sector j in time period t is given by

$$W_{kj}(t) = \theta_{kj} \; Z_k \; (t),$$

when, θ_{kj} are constants and Z_k is a wage index for occupation k. Since the θ_{kj}s are determined up to a constant multiple for each occupation, $Z_k(0) = 1.0$ for k = 1, ..., m. Hence, θ_{kj} can be interpreted as the average wage for one man year in occupation k in sector j at the base year.

Due to the problems of incorporating demographic features into the model with labor force participation rates to determine the supply of labor, Ng simply assumes that employment by occupation is given. The model will determine employment by sector for a given occupation. Therefore, summing overall sectors we get:

$$\sum_j \ell_{kj} = \ell_k^s,$$

where ℓ_k^s is given exogenously. Multiplying by Z_k, we get:

$$\sum_j Z_k \ell_{kj} = Z_k \ell_k^s.$$

Now, since

$$W_{kj} = w_{kj} \ell_{kj} = \theta_{kj} Z_k \ell_{kj},$$

so that $Z_k \ell_{kj} = \frac{W_{kj}}{\theta_{kj}}$, therefore,

$$\sum_j Z_k \ell_{kj} = \sum \frac{W_{kj}}{\theta_{kj}} = Z_k \ell_k^s.$$

W_{kj} has been calculated in Step One. θ_{kj} is a known constant, while ℓ_k^s is given. Therefore, Z_k can be determined. Employment by occupation and sector can be derived from:

$$\ell_{kj} = \frac{1}{Z_k} \frac{W_{kj}}{\theta_{kj}}.$$

Step Three. Step Three consists of calculating sectoral prices and real output. It can be shown that sectoral prices can be written as a function of the value of gross sectoral output, which was determined in Step One, the rate of Hicks neutral technical progress, which is given, the capital stock, which is fixed and given for any point in time, and the wage index, Z, which was calculated in Step Two. Therefore, sectoral prices can be determined and also real sectoral output.

Step Four. Step Four consists of calculating the distribution of family disposable income, which is implied by the solution of model. Since we calculated in Step Two employment and labor income by occupation and sector, and net return to capital by sector, the distribution of earnings and the corresponding Lorenz coefficient, LE, can be calculated. Now the problem is to relate the distribution of earnings to the distribution of disposable family income. This is

done by assuming the following relation between the Lorenz coefficients of earnings and disposable family income:

$$L_{DFY} = L_E^{\text{constant}}.$$

Disposable family income is assumed to be distributed log normally, i.e., $FDY \sim \Lambda\ (\mu_{DFY}, \sigma^2_{DFY})$. Since L_{DFY} is known, μ_{DFY} and σ^2_{DFY} can be calculated from the following formulas:

$$L_{DFY} = 2N(\frac{\sigma_{FDY}}{2}\ 10,\ 1)\ -1, \text{ and}$$

$$e^{\mu_{DFY} + \frac{1}{2}\sigma^2_{DFY}} = \text{mean household income.}$$

Therefore, the log-normal density function for DFY is now specified, so that we now know the sectoral distribution of household income.

Step Five. Step Five consists of recalculating the final demand vector which is assumed to be a function of the distribution of disposable family income. The loop is now closed. The steps are repeated until the distribution of income determined by the model agrees with that implied by the vector of final demand assumed in Step One.

Thus, the model, as specified, is static, where sectoral capital stocks are given at each point in time. To make the model dynamic, the following dynamic equations are specified:

$$cap_j(t+1) = (1-\delta_j)\ cap_j(t) + inv_j(t)$$

$$j = 1, \ldots, n,$$

where: δ_j = depreciation rates of capital in sector j, and

inv_j = real gross investment in sector j in constant prices.

Sectoral investment can be policy determined or some behavioral mechanism can be specified. Ng outlines such a mechanism which assumes that entrapreneur's desire to maintain the same rate of return to capital in the next period as in the present period, and that capital is paid the value of its marginal product.

Summary of Empirical Results and Conclusions

The model was used to analyze certain policies for improving income distribution, employment and growth performances of the

Philippine economy. This was accomplished by projecting the model from 1972 to 1985 under the different policy assumptions discussed below.

The first policy examined was a neutral policy or policy of no change. The values of the exogenous variables were projected at constant historical growth rates. The results show that changes in the composition of GDP are what one would expect from a growing economy. Shares of output of all primary sectors (agriculture, fisheries, forestry and mining) and of food manufacturing declined. Other sectors showing decline in their share of GDP are construction, trade and government. Sectors which increased their share of GDP are other manufacturing, utilities, transportation, finance, services, and housing.

The overall pattern of projected wage movements, with the exception of wages for manual workers, is for wages below average to rise relatively and for wages above the average wage to drop relatively. Therefore, an improvement in the overall distribution of income results. According to Ng,

> "The pattern of wage movements is the result of complex interactions between assumptions concerning labor supplied by occupation, rural-urban migration, and pattern of sectoral demand and sectoral outputs. The most crucial assumption is the implicit assumption of rapid rural-urban migration, or, the explicit assumption of low growth rate of rural employment."

Even though the simulation resulted in an improved distribution, poverty groups could still be identified. In rural areas, landless laborers and tenant farmers will remain in poverty. In the urban areas, manual workers can be singled out.

The second policy simulation assumed slow rural-urban migration, or, a high growth rate of agricultural employment. This experiment illustrates the important relationship between decreasing employment in agriculture, and improvement in income distribution.

The assumption employed forced a sectoral reallocation of employment in favor of agriculture, fisheries, and forestry, while sectoral employment in all other sectors declined, compared to projections under a neutral policy. Because marginal productivities of labor are lower in agriculture and fishing, the reallocation of labor results in a lower GDP. Real growth rates of all sectors, except agriculture, are lower as compared to projection under a neutral policy.

Compared with the results under a neutral policy, the income distribution is worse. The more unequal distribution of income can be attributed to worsening of rural incomes.

This exercise illustrates an important consideration in formulating agriculture development policies. Because of Engel's law stating that the income elasticity of demand for food is less than one, agricultural development and growth in agricultural per capita incomes in the long run requires a reallocation of the rural population in terms of rural-urban migration.

The third policy simulation assumed extensive labor, intensive urban development. This was accomplished by assuming increased growth rates in government investment, and increased growth rates of exports from services and manufacturing sectors. An important element of this strategy is the promotion of tourism, which results in high employment creation. The results of this exercise showed that increases in demand for labor in the low-income occupational groups result in an improvement in urban income distribution. Because this development strategy neglects the rural agricultural sector, the result was a widening rural-urban income gap and an overall deterioration in the distribution of income.

The urban development strategy of encouraging exports provided a positive stimulus to the economy in terms of demand, which stimulated investment and increased the growth rate of GDP.

The fourth policy simulation consisted of a balanced development program. This development strategy assumed increased growth rates of government construction and increased growth rates of exports from the services and other manufacturing sectors. As was seen from the previous exercise, this will have desirable income distribution and growth effect on the urban sector.

Since the major obstacle facing agricultural development is the generation of demand, it was assumed that a policy of self-sufficiency in food is pursued by the government as a long-run policy. As a result, agricultural imports were assumed to decline by 90 percent by the year 1985. By a decline of 90 percent, it is meant that actual imports, under a protectionist policy, will only be 10 percent of imports under a neutral policy, at every level of GDP. To avoid large increases in food prices, it was assumed that labor productivity in agriculture increased.

The results of the experiment showed a growth rate of money GDP, slightly higher than the projections under the extensive labor, intensive urban development program. The growth rate of real GDP was also higher, due mainly to the positive rate of technical progress in the agricultural sector. Sectoral GDP share of agriculture and food manufacturing responded directly to import restrictions on food.

The agricultural development program has a slight, but positive impact on income equality. In fact, the Lorenz coefficients of distribution for earnings, income, and consumption are lower than for the corresponding coefficients projected under a neutral policy. Since the program of labor intensive urban development resulted in

a slight deterioration of income equality, it may be concluded that the incorporation of the agriculture development program has more than compensated for the undesirable income distribution effects of the extensive labor, intensive urban development program.

Using the results of the above simulation exercises, Ng makes the following policy recommendations:

1. It encourages sustained rural-urban migration. Migration results in the equalization of rural and urban incomes. Since the marginal productivity of labor is higher in the urban sector, rural-urban migration results in a more efficient pattern of output. Therefore, growth of total output is increased.

2. To compliment the policy of sustained rural-urban migration, an extensive labor intensive urban development program is recommended to provide productive employment for the migrants. An important component of this program is accelerated industrialization. Low capital intensity is desirable but not necessary if large export markets are opened up which would allow extensification of industrialization. The emphasis of the program should be on exports (especially tourism) and utilization of low skill workers. "The savings problem can be solved by relying heavily on foreign capital and multinational corporations. Foreign investment should, therefore, be encouraged." A major instrument in the urban development program is government construction, which is mainly directed at the labor intensive construction sector.

3. In order to prevent an increasing gap between rural and urban incomes, an agriculture development policy is needed. The usual agriculture development policies are recommended. They consist of improved seed varieties, increased use of fertilizers and insecticides, irrigation projects, and agriculture research and extension. These are designed to increase labor productivities in the agriculture sector. Given a slow growth of agriculture employment, productivity increases imply increases in per capita income. Also, if imports of food are restricted, increases in food prices will redistribute income towards the rural sector. Thus, overall income distribution can be improved.

PART III: EFFECTS OF RURAL PROGRAMS ON EMPLOYMENT AND INCOME DISTRIBUTION

Alternative Technologies

One important approach to the problem of income distribution and rural development is illustrated in a study by Dambe [1974]. The methodology was partially developed in the course of a Central American study for Guatemala in 1971 by the UN-GAFICA[1] team, of which Dambe was a part. The approach was formalized in Rome at FAO headquarters by Erik Thorbecke [1969]. The basic approach as well as the conclusions will be presented below. This should accomplish two objectives: (1) present a methodology which is useful in evaluating employment, income distribution, and rural development alternatives, and (2) indicate the kind of conclusions and insights which can be obtained using this methodology.

When faced with evaluating a study using this methodology, one is struck by the lack of a rigid mathematical model where all variables are related by a set of simultaneous equations which can be solved for the relevant policy variables required to achieve a given objective. Instead, the approach takes the form of an iterative set of conputations which are subjected to various consistency checks to insure that the values computed are feasible and consistent with other economic variables calculated in other steps. The main value of this approach is that it can be done with little or no computer capacity. This can be a very important consideration for many LDCs. While the approach lacks the elegance of a formal mathematical model, it can be no less complex or no less useful.

The basic proposition of the approach is that an improvement in the distribution of income in most LDCs is a necessary condition for any further economic development to occur if development means that the entire population receives benefits from economic growth. Given a high rate of population growth and growth unemployment, employment creation is synonomous with an improvement in the distribution of income. While it is recognized that the long-run solution to the employment problem lies in creating jobs in the nonagricultural sector, agriculture must play a major role in the short run. The importance of agriculture is implied by the following propositions.

1. Population and labor force are growing rapidly and cannot be checked in the next generation or so.

2. Productive employment outside agriculture cannot be

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[1]United Nations -- Grupo Asesor de la F.A.O. Para La Integracion Economica Centro-Americana; F.A.O.'s advisory group for the economic integration of Central America.

increased at a rate which would absorb expected increments to the urban labor force.

3. Expansion of nonagricultural output is limited by the market, which can be greatly increased if income and employment in the agricultural sector were increased.

4. Generation of employment is most successful if both agricultural and industrial development go forth in a process of balanced growth.

5. Technology for nonagricultural production is generally imported from industrialized nations where labor is scarce so that the technology is labor-saving. This reduces the employment-generating effects of industrialization while the technology of agriculture is more flexible. In other words, intermediate technologies which are yield-increasing as well as labor-using are possible in the case of agriculture.

6. There is a wide scope for structural change in agriculture which can be brought about by land reform, colonization, cooperatives, etc.

7. Finally, given world food shortages, agriculture is becoming more important to the entire world and there is less chance of importing food, so that it is important that LDCs become self-sufficient

Employment generation in agriculture is attempted in three major ways:

1. Stimulation of demand for agricultural output which in turn stimulates demand for labor.

2. Changing the factor proportions so that more employment is generated by a given level of production.

3. Increasing nonagricultural employment in rural areas.

The basic logic behind the methodology being described can be simply illustrated by the following assumed cause-effect relationship: income distribution determines demand, demand determines output, the production of output generates employment, which in turn affects the distribution of income and closes the loop. In summary, the basic assertion is that agricultural production and employment can achieve rapid growth if an effective demand is "stimulated by suitable agricultural policies eliciting technological and institutional change, which brings about greater equality in the distribution of income."

The overall framework of the approach is represented in Figure 1. The planning process can be divided into the following major stages (referring to Figure 1).

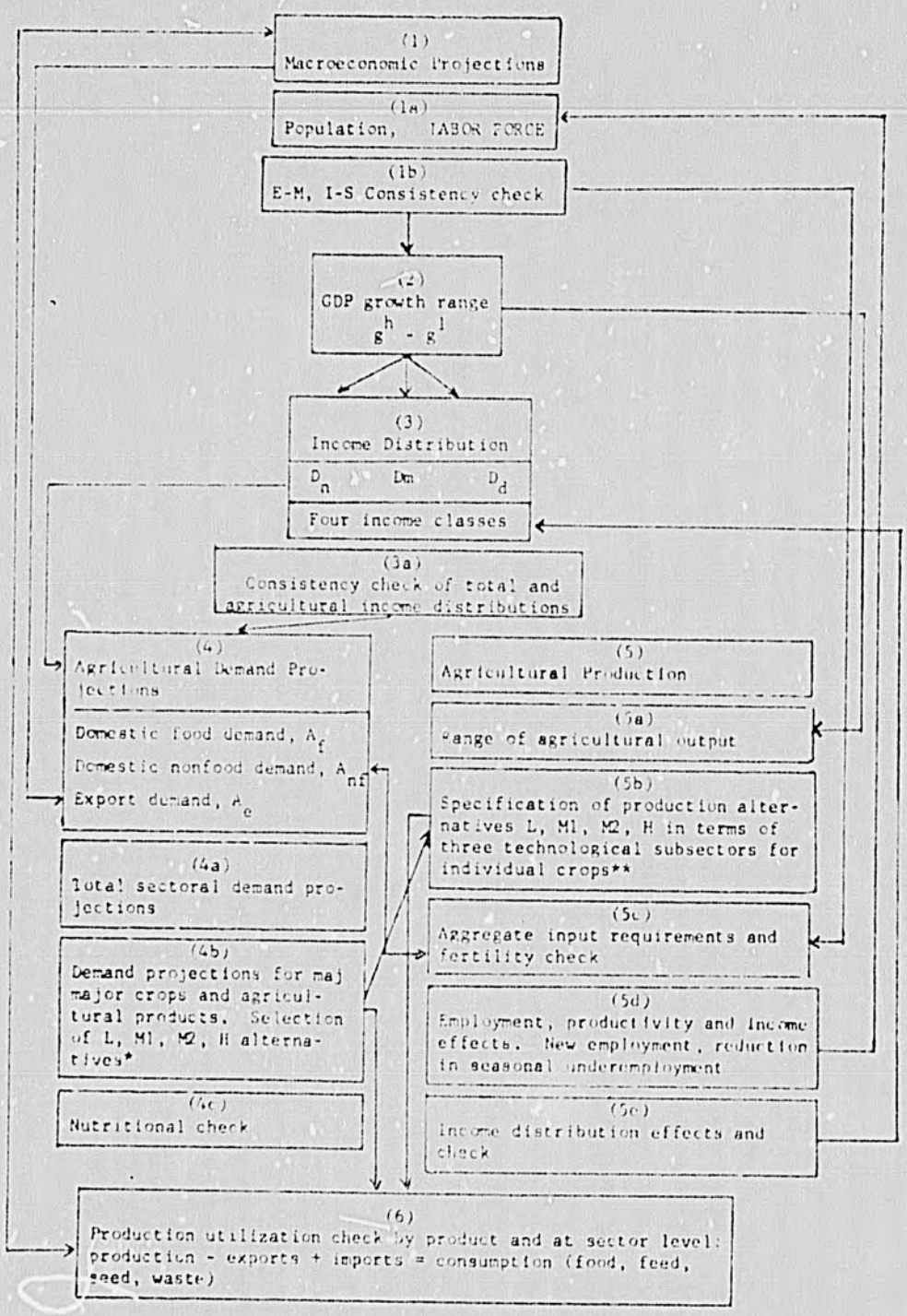


Figure 1. Consistency Framework

1. An economy wide macro-economic model is used to obtain projections of the important macro aggregates in the economy.

2. The projections obtained above depend upon the values of projections obtained for the exogeneous variables. Typically, the most important of these variables is exports. Therefore, a range for target GDP for the target year is obtained by substituting an optimistic and a more pessimestic range for exports into the macro-economic model. Comparing this range of GDP with the base year values results in a range of GDP growth.

3. The third stage consists of specifying a target size distribution of income. Since this specification is rather arbitrary, three different redistribution schemes are postulated representing less radical to more radical changes in the distribution of income.

4. Once the macro-economic variables have been obtained and income redistribution targets specified, demand for agricultural products under the three income redistribution alternatives can be estimated.

5. Specification of production supply plans are then stated in terms of three technology levels, which have different factor intensities. This is done in two steps. First, the supply capacity and input requirements of agriculture should be checked for overall consistency at the sector level. The objective of this overall check is to provide a rough check of the feasibility of satisfying the projected agricultural demand and the given changes in the overall distribution of income. This may also be used to provide a target growth rate in agricultural production. The second step consists of specifying production alternatives at the commodity level for the target year four supply alternatives, or production plans, for each commodity. The methodology, at this stage, yields a number of production alternatives and growth rates to be matched with corresponding projections on the demand side. A feasibility check along these lines will help to eliminate supply alternatives which are not economically feasible. Those that remain can be examined for employment and income distribution implications.

6. Estimation of employment and income distribution effects of the feasible production plans. Central to this stage is a consistency check between income distribution targets specified at the outset and actual income distribution, resulting from the proposed production plan. This check consists of an iterative procedure until convergence is achieved and feasible production alternatives are obtained.

The major conclusions arising from applying this methodology to the Colombian economy are as follows:

1. Upon examining the labor absorptive capacity of the industrial sector, it is apparent that unemployment will continue to increase. It was concluded that no change in the distribution of income and no significant increase in employment would result from increasing the size of the manufacturing sector. "in fact, it was shown that the growth of manufacturing output could not be expected to absorb the increments to the labor force, let alone the already existing large backlog of unemployment." The conclusion then, is that we must turn to the agricultural sector for any solution to the problem. The study showed that there is a "sizable development potential" in terms of productive employment in the traditional sector. Dambe then concludes "that the identification of an appropriate technology within agriculture and supported by complementary policy measures constitutes perhaps the sine qua non of Colombia's future economic and social development."

2. What is needed to develop the potential of the agrecultural sector is to transform production in the traditional subsector by choosing a technology which is both labor saving and yield increasing. If this can be accomplished, incomes can increase and the distribution of income will improve. The basic conclusion of the study was that "significant" improvement was possible.

> "Under the high growth alternative, the growth of agricultural employment was projected to increase at about 8.5 percent per year in contrast to only a 2.2 percent increase if present trend conditions (no change in the structure of agricultural production) were to prevail. The growth rate of output would increase from 2.8 to 4.3 percent a year. As a consequence, the growth rate of labor productivity would increase from 0.4 percent a year under trend conditions to 1.3 percent per year under the high growth alternatives. In terms of income distribution, the high growth alternative would change the existing situation to a more equal distribution quite drastically, although the exact effects in the four income classes could not be determined."

Increasing the Incomes of Traditional Farmers

A typical situation found in most LDCs is one where a large portion of agricultural activity (at least from the standpoint of number of farmers) is carried out on extremely small plots of land using traditional techniques and cultivating traditional crops. It is clear that the major constraint on individual family income is the smallness of the plots of land. In many areas, agrarian reform programs have dealt, or are dealing with, this problem. However, in many countries, redistribution of land is either politically infeasible or proceeding at a very slow rate. The former is the case for Guatemala. A relevant question to ask is: Given the present distribution of land, how much can small farm incomes be increased by applying new technologies and introducing new crops? At the present time, a Basic Grains Program is being implemented in the Guatemalan Highlands. The target group of the program is the large number of farmers who have to make a living by working small plots of land. Seventy-five percent of farmers in 9 highland departments live on farms smaller than 3.5 hectares [Merrill, 1974].

The Basic Grains Program has two basic objectives: (1) to provide knowledge through extension activities, and, (2) the provision of credit. A recent study attempted to evaluate the potential of the Basic Grains Program [Johnston, 1974]. The purpose of this section is to summarize Johnston's methodology results, and conclusions.

The basic objective of the study was to determine the maximum income a small farmer could expect to earn by employing a traditional set of crops and production activities, and how much income could be increased by employing new activities embodying new high-yield technologies. The methodology employed in the study consisted of building a linear programming model where the activities and constraints were those of a "typical" small farm. The objective function to be maximized was net farm income. The model is quarterly, but production activities are constrained such that all farm jobs and most resources are allocated to a specific quarter of the year. The model was constructed in such a way as to allow almost the entire analysis to be done using the same basic "A" matrix while changing the available set of resources. The primary resources available were land, labor, capital (working capital, which was the sum of savings and credit), and knowledge. Knowledge was included in the model by specifying additional production activities available to the farmer. As the farmer's knowledge of new technologies grows, he has a larger set of activities to choose from. By restricting the farmer to the traditional set of activities, knowledge is built into the model as a constraint. Increased knowledge can be simulated by adding activities to the model which embodies higher level technologies.

The study is focused primarily on production of traditional crops, such as corn, milpa, wheat, and potatoes. Because of the many combinations of resource packages which could be made avail-

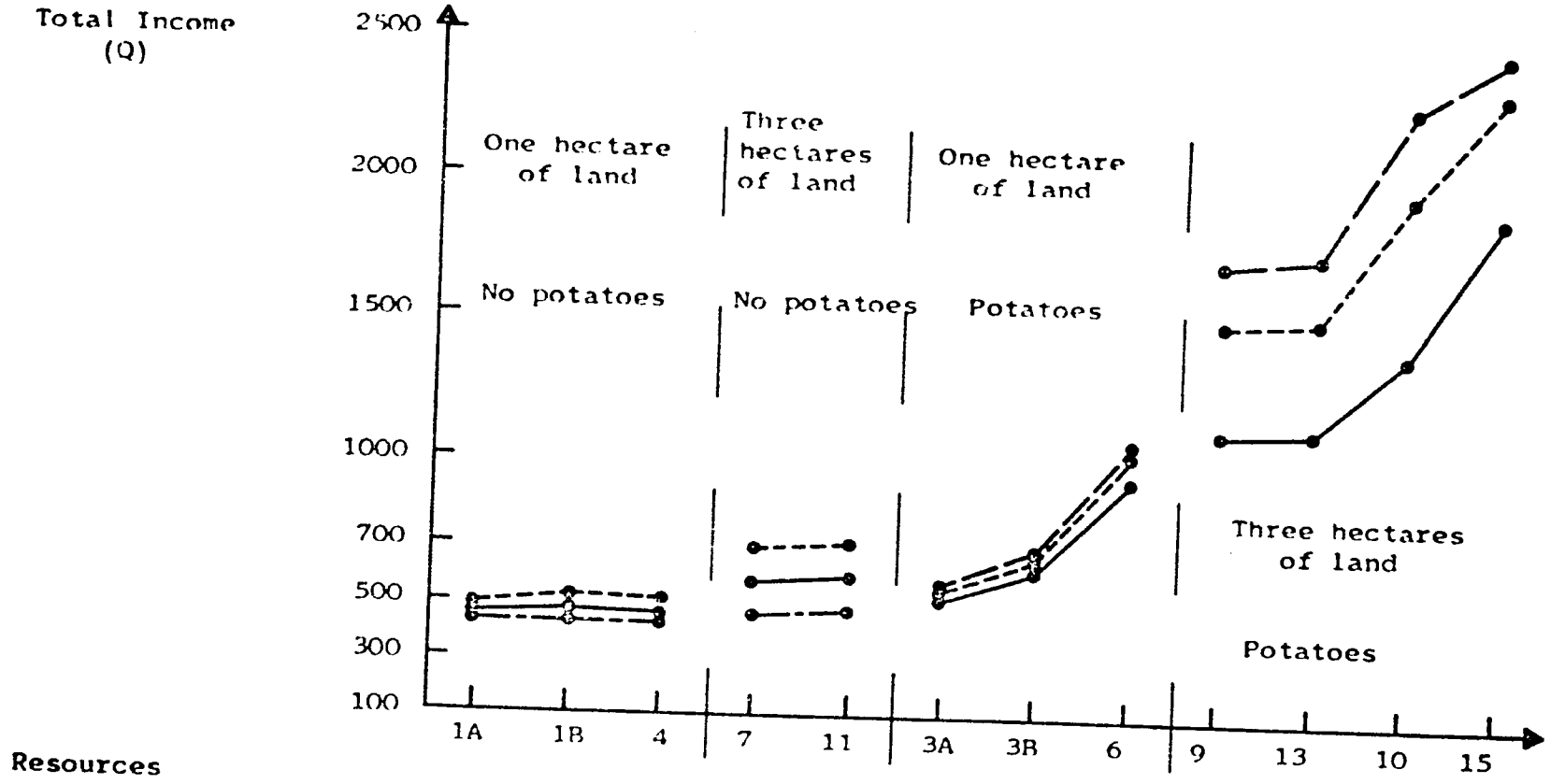
able, it was necessary to divide the set of resources into four subsets. Each of these subsets represents a different kind of farmer, so that the effect of increased credit or increased knowledge is different for each one. Therefore, four different "typical" farmers are examined: (1) the nonpotato farmer with one hectare of land, (2) the nonpotato farmer with three hectares of land, (3) the potato farmer with one hectare of land, and (4) the potato farmer with three hectares of land. The reason for distinguishing between a potato farmer and a nonpotato farmer is because potato farmers are able to make substantially higher incomes than nonpotato farmers.

Four different levels of crop knowledge were assumed. Each level of crop knowledge is built into the model as a constraint, and each cropping activity requires a specific level of crop knowledge. These levels of crop knowledge are: (1) TL0, a traditional technology used today characterized by a low use of chemicals, (2) TLI, a present-day intermediate technology characterized by use of some fertilizer but little else; and (3) TL2, a present-day high technology in which farmers use more fertilizers, increase their planting density, and use insecticides, herbicides, and fungicides as recommended by extension agents and others, and currently used on most demonstration plots; (4) TL3, an activity required by the highest level of potato production.

The most important solutions resulting from the various permutations of the resources are summarized in Figure 2. Conclusions based on these solutions are listed below.

1. Careful study of the results reveals the striking complementarity of resources. For example, giving a nonpotato farmer credit and an additional two areas of land but holding technical knowledge at TL0 (moving from solution 1A to solution 7) increases incomes by only $37.00. However, if, in addition to the credit and additional land, technical assistance is also provided, total farm increases to about $7.00. All three ingredients are needed if the farmer is to achieve a substantial increase in income. Solutions 1A and 4 show that giving a nonpotato farmer with just credit of just technical assistance, or both, without land, does little to increase income. Therefore, we conclude that the Basic Grain Program which provides both credit and technical assistance will not significantly benefit a farmer with only 1 hectare of crop land. This is particularly significant when one considers that 45 percent of the farmers in the 9 highland departments, which Merrill [1974] analyzed, lived on farms less than 1.4 hectares.

2. The shadow prices on land for solutions in which the farmer has crop knowledge TL1 and TL2 are higher than when the farmer only has crop knowledge TL0. This again



Resources	1A	1B	4	7	11	3A	3B	6	9	13	10	15
Ha. of potato land	0	0	0	0	0	1	1	1	1	1	3	3
Ha. of land	1	1	1	3	3	1	1	1	3	3	3	3
Credit	No	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Savings	50	150	50	50	50	50	150	50	50	50	50	50
Local laborers available	10	10	10	0	10	10	10	10	0	10	0	10

——— Crop knowledge level TL0

——— Crop knowledge level TL1

- - - - - Crop knowledge level TL2

— — — Crop knowledge level TL3

Source: Johnson (1974) page. 283.

Figure 2. Total Family Income Under Different Technologies

illustrates the complementarity of technical knowledge and additional land, but also indicates that the Basic Grains Program holds considerable potential for helping farmers with two, three, or more hectares.

3. The results of Johnston's analysis indicate that a nonpotato farm family with less than three hectares of land cannot earn $1000 per year, which is the target level of income often mentioned in relation to the Basic Grain Program. According to Johnston, farmers would have to have (1) adequate working capital, (2) crop knowledge of TL2, and (3) four hectares of land before the target level of $1000 per family could be achieved (for a nonpotato farmer).

4. Referring to Figure 2, it is clear that working capital is the major constraint for the potato farmer. Potato farmers with only one hectare of land can benefit substantially from credit assistance. Comparison of solutions 3A and 6 also indicates that increased working capital enables the farmer to take full advantage of technical assistance, but the effect is relatively small. However, if the potato farmer is given two additional hectares of land, the effect of technical assistance is dramatic.

5. One of the major goals of rural development is employment creation. The results of this study indicate that provision of credit and technical assistance will have positive employment creation effects, even for a nonpotato farmer with only one hectare of land. Providing the nonpotato farmer with one hectare of land with credit reduces local labor sales by 33 man days and increases on farm employment by the same amount. Giving the farmer more land causes the amount of labor sold locally to decline even more. However, one hectare of land is still not enough to fully employ a farm family throughout the year. According to Johnston, "if farmers are to be fully employed in traditional agriculture, the typical farm size will need to be expanded to three or more hectares.

6. In conclusion, it appears that one of the major effects of the Basic Grains Program will be to cause land to replace credit and knowledge as the primary constraint on production on the traditional farms. Perhaps success in this program will create pressure for a meaningful land reform. In the absence of land reform, the only way to increase plot size in the traditional sector is a large volume of out migration to the other sectors, which implies the importance of

a balanced approach to development planning so that jobs are created outside the agricultural sector.

A serious problem with this study, of which Johnston is fully aware, is that what might be attained by a single farmer might not be possible for all traditional farmers as a group. In other words, one needs to look at this problem from a general equilibrium perspective. Implicit in Johnston's analysis is the assumption that each farmer can sell as much of his produce as he likes at a constant price. This clearly will not be true for the sector as a whole. Therefore, a possible result of programs like the Basic Grains Program and/or land reform might be to reduce agricultural prices to the point where individual farmers are left no better off. From the analysis, one might be tempted to recommend that farmers produce more potatoes. However, only a limited number of farmers have good enough land to produce potatoes and, even if they all could, the price of potatoes would undoubtedly fall. The profitability potato production in the model is due to the high price resulting from the present limited potato production, so that only relatively few farmers can benefit from producing potatoes. In conclusion then, when considering the problem from a general equilibrium perspective, demand considerations become extremely important and should be endogenous in the model.

Another important assumption implied by this study is that farmers and their families are fully employed either on their own farm or outside the farm. Outside employment can be obtained at a constant wage rate. Again, the results obtained may be different for a general equilibrium framework. This study is an important contribution to understanding peasant agriculture but the result must be considered tentative, until a more general equilibrium model can be used to test these results.

PART IV: A DYNAMIC MULTISECTORAL LINEAR PROGRAMMING MODEL OF GUATEMALA

Guatemala: The Problem

Guatemala is a small Central American country which lies just south of the Yucatan Penninsula. It is bounded on the north and west by Mexico, on the east by Belice, to the south and east by Honduras and El Salvadore, and on the southwest by the Pacific Ocean. It is about the size of the state of Louisiana and has a population of about 4.3 million people.

The economy of Guatemala has been characterized as the "prototype" of a dual economy. A dual economy is defined as one where a dynamic modern sector exists alongside a traditional or subsistence sector [Fletcher et.al., 1970]. The relation between dualism and the distribution of income is illustrated by a study by Adelman and Morris [1971] which finds that the allocation of income to the poorest 60 percent of the population is related to the extent of dualism. The greater the degree of dualism the smaller is the share of income going to the poorest 60 percent of the population.

Dualism is most pronounced in the agricultural sector which is characterized by the continual existence of traditional large land holdings (latifundia) and numerous uneconomically small land holdings (minifundia). This system of latifundia-minifundia is one of the continuing legacies of the old colonial system and subsequent years under dictatorships. The following statement would seem to apply to Guatemala.

> In those regions where the colonial agrarian system took far stronger hold, as in many Latin America countries, and where export industries served mainly to strengthen the position of the powerful urban classes, modern industrial development has, in many cases, been superimposed on the traditional agrarian structure. The result is a highly distinctive coloring to the resulting patterns of income distribution, which are amongst the most unequal to be found [Baster, 1970].

The traditional sector is made up largely of Indian farmers who make a living by working small plots of land in the highlands and supplement their earnings working on the large plantations or in nonagricultural activities. The term "Indian" is more than a racial designation but a cultural one as well. Indians are defined as those descendants of the precolonial civilizations inhabiting Central America who have not adopted the characteristic features of modern western culture [Fletcher et.al., 1970]. People, although racially would qualify as Indians but who have begun to adopt or have already adopted modern ways in such areas as dress, religion, customs, etc., are classified with the rest of the population as

"Ladinos." According to the 1964 census of population, Indians constituted 43.3 percent of the total population, which is an indication of the extent of economic and cultural dualism in Guatemala.

The development problem in Guatemala has both cultural as well as economic dimensions, but the statement that "development in the 1970s must include an improvement in the distribution of income" would apply here. More specifically with almost 50% of the population made up of Indians, who are defined as being outside the main economy and culture and poor ladino farmers who make up the rest of the traditional sector, an improvement in the distribution of income in Guatemala would have to include development of the traditional sector.

The Size Distribution of Income

Data on the personal distribution of income in Guatemala are scarce. No official data are published by the government of Guatemala, but GAFICA[1] presents some data on the distribution of income which were derived from data collected by the Social Security Institute (IGSS) of Guatemala. These data only include people who are participating in the Social Security System. This would include salaried workers and wage earners working for the government or larger companies. Self-employed people who do not choose to participate in the program and many campesinos (peasants) who do not work on the large fincas are excluded. Most likely both very poor people and very rich people would be excluded from this sample. It is, therefore, reasonable to expect that the information derived from this data would underestimate the degree of income inequality. This is because the poor that are excluded would earn a smaller percentage of income than their percentage of the population, and the rich who are excluded would earn a larger share of total income than their share of the total population. Table 1 presents percentage per capita income per decile of the population (deciles are ranked from low to high income) and also cumulative percentage figures. According to the figures given, the lowest 50% of the population in terms of per capita income receive only 12.7% of total income while the richest 5% receive 85.2% of the total income.

In addition to the data presented by GAFICA it is possible to derive an estimate of the distribution of income in Guatemala from the income expenditure data reported in two budget studies carried out by the Instituto de Investigaciones Economicas Y Sociales of the University of San Carlos in Guatemala. These two studies, one for the rural population [Orellana, 1966] and one for the urban population [Orellana, 1972], provide the income consumption data for

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[1] Grupo Asesor de la F.A.O. Para La Integracion Economica Centroamericana F.A.O.'s advisory group for the economic integration of Central America.

estimating the consumption functions of the model. These studies will be discussed in more detail later.

TABLE 1. Distribution of income in Guatemala, 1968.

	GAFICA Data		
Decile of Population	% Income in Decile	Cumulative % of Population	Cumulative % of Income
1	0.5	10	0.5
2	1.5	20	2.0
3	2.5	30	4.5
4	3.0	40	7.5
5	5.2	50	12.7
6	5.3	60	18.0
7	8.0	70	26.0
8	10.5	80	36.5
9	16.0	90	52.5
10	47.5	100	100.0
Top 5%	35.2		

The income distribution data resulting from compiling the data in these two studies are presented in Table 2.

TABLE 2. Distribution of income in Guatemala, 1966-69.

	Derived From Budget Study Data		
% Families (low income to high)	% Income	Cumulative % Population	Cumulative % Income
34.0	6.2	34.0	6.2
16.3	6.7	50.3	12.9
12.2	8.4	62.5	21.3
9.3	8.9	71.8	30.2
10.7	14.4	82.5	44.6
6.9	13.3	89.4	57.9
5.6	14.8	95.0	72.8
1.9	7.2	96.5	80.0
1.4	6.8	98.3	86.8
1.7	13.2	100.0	100.0

Using data from the budget studies gives very similar results to those derived using IGSS data (used by GAFICA). The poorest 50.3% of the population receives 12.9% of total income. The simi-

larity of the results obtained by the two sets of data is even more striking when the income distribution data is represented by Lorenz curves, which are shown in Figure 3. The GAFICA data seems to indicate a slightly more unequal distribution of income at higher levels of income than the budget study data. The fact that the methods used to calculate these distribution (i.e., random sampling and analysis of reported wage data) are different but give similar results increases our confidence in these estimates.

The fact that 50% of the families in Guatemala receive only about 13% of total income while the richest 5% of families receive about 30% indicates a high degree of income inequality. This is even more evident when income distribution data from Guatemala is compared with that of other countries. Figure 4 shows the Lorenz curves for Guatemala, Great Britain, the United States, Brazil and Mexico. The poorest 50% of families in the United States and Great Britain receive 23.0% and 26% of total income, respectively, while the top 5% receive about 18% and 13%, respectively.

Another measure of inequality of income, which is related to the Lorenz curve is called the Gini Coefficient. The Gini Coefficient is a summary statistic, which is used to measure the inequality of income distribution, that is calculated by taking the ratio of the area between the Lorenz curve and the 45° line of perfect income equality. The value of this coefficient ranges from 0.0 - 1.0 where a value of 0.0 and 1.0 indicates perfect income equality and perfect inequality, respectively. Table 3 presents the Gini Coefficients for Guatemala and other countries which gives some basis of comparison.

TABLE 3. Gini coefficients of income concentration by country.

	G
Guatemala	0.58[a]
Brazil	0.57[c]
Mexico	0.53[b]
United Kingdom	0.40[c]
United States	0.40[c]
Norway	0.36[c]

[a]GAFICA
[b]Cline
[c]Thorbecke and Sengupta

The Distribution of Land

Faced with the fact of a high degree of inequality in the distribution of income in Guatemala, one turns to the question of what

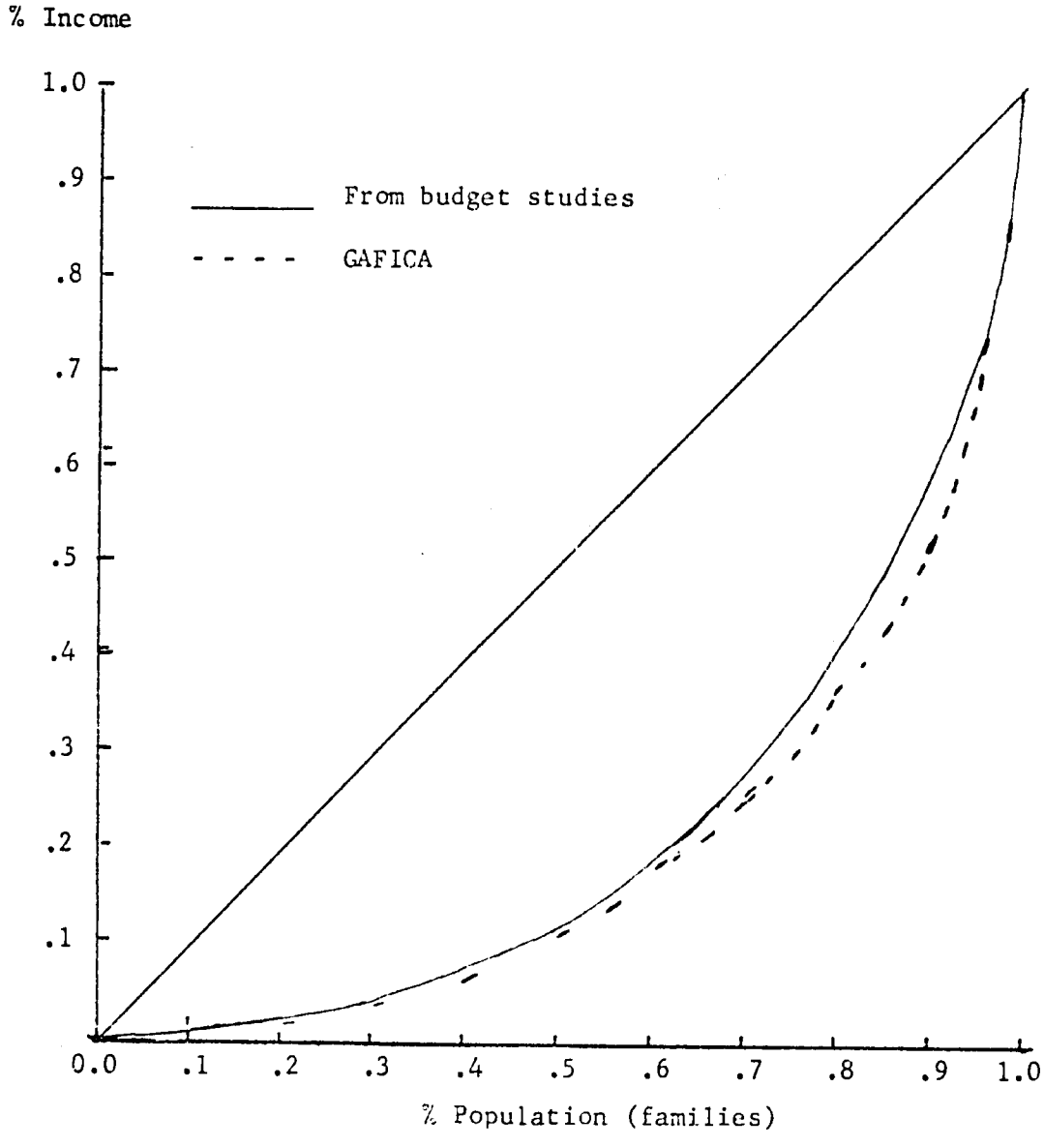


Figure 3. Comparison of Lorenz Curves Derived From GAFICA and Budget Study Data

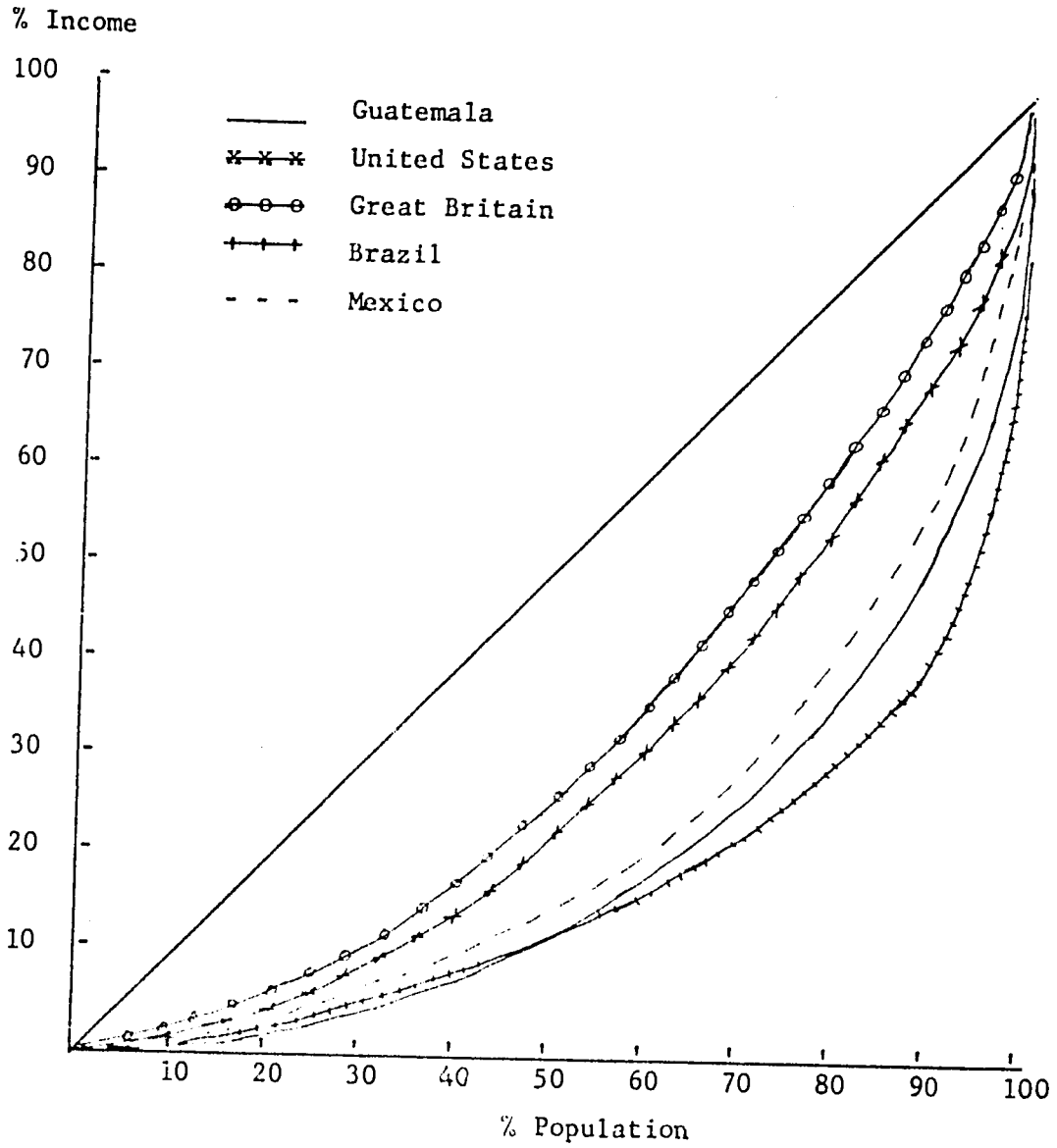


Figure 4. Lorenz Curves for Guatemala,[a] United States and Great Britain

[a]Using GAFICA data

Source: Guatemala: GAFICA
United States: University of Michigan, Survey Research Center, Survey of Consumer Finances
Great Britain: Cline

factors influence the distribution of income in Guatemala. This question, of course, would be very difficult to answer completely and indeed could be the subject of another dissertation. However, one outstanding characteristic of Guatemala, which is not unique among Central and Latin American countries, should shed considerable light on this question. This characteristic is the highly unequal distribution of land.

Distribution of land becomes even more important in explaining the distribution of income when one considers that 68.2% and 65.4% of the total labor force was employed in agriculture in 1950 and 1964, respectively [Direccion General de Estadistica, 1964].

Table 4 presents the number and size of farms according to the 1964 agricultural census [Direccion General de Estadistica, 1968].

TABLE 4. Guatemala: number and size of farms, 1964.

Farm Size Class	Number of Farms	% of Farms	Area	Percent of Land	Average Size
Less than 0.70 ha[a]	85,083	20.0	32,619.2	0.9	.38
From 0.70 to 6.99 ha	279,797	67.0	607,855.6	17.7	2.17
From 6.99 to 45.13 ha	43,656	10.0	648,900.2	18.8	14.86
45.13 to 902.51 ha	8,420	2.0	1,258,545.2	36.6	149.47
More than 902.51 ha	388	0.9	894,600.4	26.0	2,305.67
Totals	417,344	100.0	3,442,520.6	100.0	8.25

[a]1 ha (hectare) ≅ 2.5 acres

Farm sizes are grouped together in a classification scheme used in the Agriculture Census and also United Nations reports. This scheme classifies farm size relative to ability to fully employ an average farm family productively during the year. The word productivity is important here because obviously an entire family may work on the finca when one man could handle the work alone. In this case, the marginal productivity of the other family members would be equal to zero.

According to this scheme, any farm less than 6.99 hectares would be classified a subfamily farm, too small to sustain a family (less than two laborers).[2] Farms of size 7 to 45 hectares are class-

[2]There are exceptions to this rule. For example, one vegetable farm of one hectare can generally fully employ a family. However, much of the traditional agriculture can be characterized as "milpa" farming, which is growing mainly corn and squash and beans planted in the rows with the corn. Also, wheat is grown in many areas and is vertually the only "cash crop" of the highland Indian. These crops are less labor intensive than vegetable farming and much more common so that classification scheme used is probably quite realistic.

ified as family-size farms. Farms of size 45.1 to 902.51 and greater than 902.50 hectares are classified medium and large multi-family farms, respectively [Manger-Cats, 1966].

Subfamily farms, or what will be referred to as the traditional or subsistence sector throughout this paper, account for 87.0% of all farms, while accounting for only 18.6% of the land, while 388 or 0.9% of the largest fincas possess 26.0% of the land. It is apparent that the distribution of land is even more skewed than the distribution of income.

Economic and Cultural Dualism

The most important economic sector of Guatemala is the export agriculture sector which produces mainly coffee, cotton, and bananas. There is strong evidence that the prime factor influencing investment in Guatemala is the performance of this sector, and has led to Guatemala's economy being classified as an "export led" economy [Fletcher et.al., 1970]. Most of the export products which are produced come from the large plantation type farms. It is this group which, though relatively small in number, takes a large share of the land holdings. Over the period of 1950-1966 export crop producation grew at a rate of 6.6% while production of domestic consumption crops grew at a rate of 4.1%.

It is the existence of this dynamic modern agricultural subsector existing side by side with the small traditional agricultural subsector, which enables Guatemala to be classified as the "prototype" of a dual economy. With approximately 56% of the population in the subsistence agriculture sector and many more extremely poor in the large cities who came from this sector because of lack of employment opportunities, one must conclude that the distribution of ownership of land is an extremely important factor influencing the overall distribution of income and wealth. According to Adams, "whether one is a subsistence farmer on his own or rented land, an agricultural laborer on a coffee or cotton farm, or an upper-sector entrepreneur looking for a prestigious and profitable investment, land is the base. One of the major problems of access to wealth is simply getting access to land" [Adams, 1970].

As in any capitalist economy, the distribution of wealth not only affects the distribution of income directly through the rate of return on wealth but also indirectly through influencing social and cultural factors which have an affect on the distribution of income in the larger run. It was hypothesized (and accepted) by Manger-Cats

> ... that most power is concentrated in the hands of those who control the land or are intimately connected with this group, and that this results in a social order in which primary producers have no effective oppor-

> tunities for decision making or for acquiring the capacities for making rational decisions.

He concludes:

> ... that the present land tenure structure of Guatemala is part of a complex matrix of social and cultural factors which tend to obstruct the economic and social development of the country.

In his study, Manger-Cats comes to two important conclusions related to the relationship between land ownership and socio-political factors which have long-run effects on income distribution:

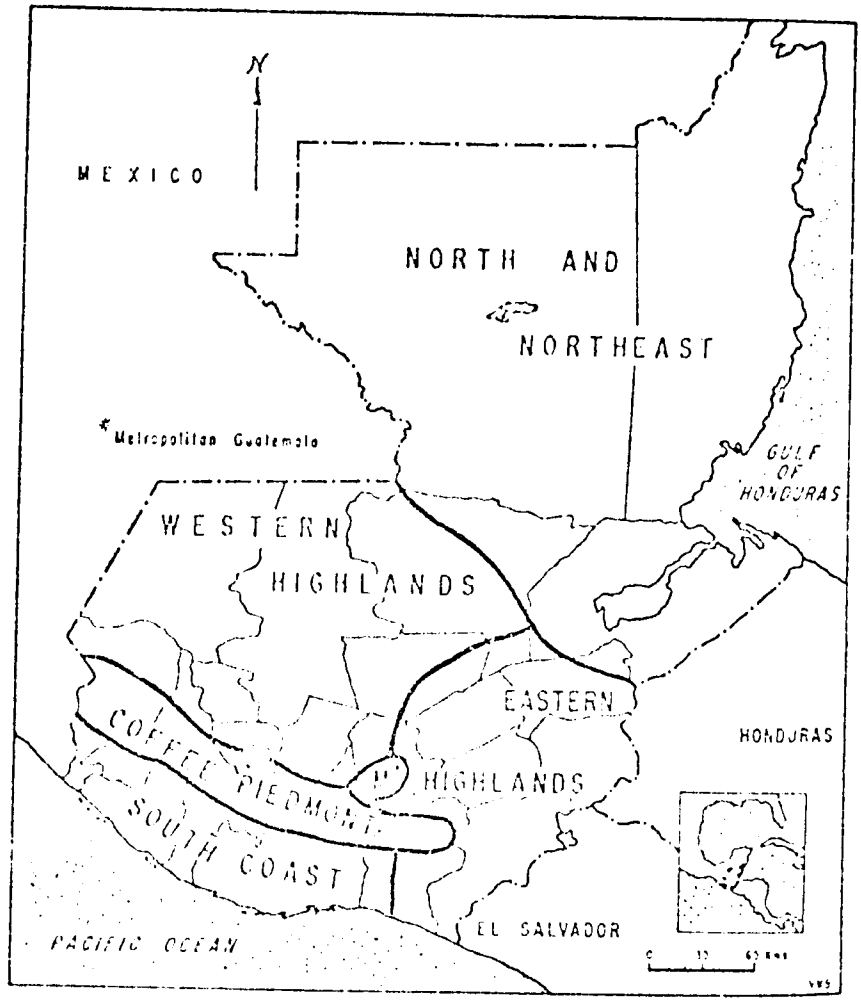
> The access to public and private services, including education, technical services, transportation facilities, credit and the like increases with the size of holdings.
>
> The majority of those with low incomes, little education, limited resources and access to few services are politically powerless, or at least inactive, particularly at the national level but even largely so at the local level ... [Manger-Cats, 1970].

We then have a vicious circle where the distribution of income determines access to more wealth, particularly land which in turn influences the distribution of political power and the means of increasing human wealth such as education. Also the access to important factors such as credit and technical assistance are affected. These factors then influence the distribution of income both in the long and short run.

In light of the above arguments it seems reasonable to conclude that any policy aimed at improving the lives of all Guatemalans and at bringing about a more equitable distribution of income, at least in the long run, will have to come to grips with the problems which are associated with the land tenure system.

Identification of the Sectors

The model will include three sectors: traditional agriculture, commercial agriculture, and nonagriculture. A sector will be more than an income and production concept, but a cultural one as well. Although the lines between these sectors are not distinct, the two agricultural subsectors can be delineated geographically. The map shown in Figure 5 shows five major geographical regions in Guatemala. The north and northeast regions are lowland areas consisting of jungle. The approximate percentage of the total population for this region in 1964 was 3.2. This region is relatively unimportant as far as agriculture is concerned. The western highlands, which is



Source: Adams

Figure 5. Major Geographical Regions of Guatemala

often called the Indian Highlands, is comprised mainly of small land holdings. The majority of the population is Indian, and indeed several departments in this region have over 90 percent Indian populations. The eastern highlands differ from the western highlands in that the population density is much less. Instead of a predominance of small land holdings, the eastern highlands have a much broader spectrum of small, middle-sized, and large producers. The percentage of Indians in this region is less than 50 percent of the total population in the region. There are, therefore, significant cultural differences between these two regions. The coffee piedmont consists of an area along the south slopes of the mountain range running through the central part of Guatemala. This land is most suited to growing coffee and it is here where most of the large coffee fincas are located. It is to this region that most of the seasonal migration of farm laborers from the western highland occurs. The south coast is tropical sea level alnd where sugar cane and cotton are most important. The remaining region consists of metropolitan Guatemala, Guatemala City being the capital of the republic [Adams, 1970]. The three sectors of the model will now be more precisely defined. It is necessary to delineate the sectors as rigorously as possible in order to estimate the parameters of the model for these sectors.

The Traditional Sector

The traditional sector is defined as consisting of all families who operate farms classified as subfamily size farms, which account for about 87 percent of all farms in Guatemala (364,879 farms according to the 1964 agricultural census). It will be recalled that subfamily size farms are defined to be those less than 7 hectares in size. Most of these small farms are found in the western highlands of Guatemala. Indeed, if one were forced to locate the traditional sector geographically, the western highlands would be the most accurate choice both because of the high concentration of small farms and also because of the high proportion of Indians living in this region. These two factors distinguish the western highlands in both an economic and cultural sense.

In addition to these people, another group of families, who have no land but would be of the same cultural class, are included in the traditional sector. These families are officially denoted "trabajadores sin tierra" or workers without land who work principally on the large farms. There were about 68,700 families in this category in 1964.

Obtaining an estimate of income per family for this sector is very difficult. No data is published officially by the government or its agencies, so the only information available is from surveys taken by individuals or private groups. Manger-Cats estimates the average per family income of the minifundista in the western highlands at about Q520.00 per year. This includes income both in kind

and in specie and also from sources outside the farm. He estimates the income per family for traditional farms on the coastal plain to be about Q967.00. Although the average area of the minifundia in the lowlands was nearly twice that of those of the highlands, the value of products is about three times as high on the coastal farms. He attributes this more than proportional difference to better soils and good climatic conditions. However, according to the 1964 census of agriculture, there were only about 30,000 subfamily size farms in the south coastal region accounting for about 12% of the total number of subfamily farms. Therefore, taking a weighted average based on these weights gives an average per family income of Q573 for the sector as a whole (taking into account the laborers without land, the average would be slightly less). However, another study (IDESAC) [Oehler, 1971] presents a less optimistic estimate of Q258.00 per family for highland Indian families. However, the average size of farms in this study was 1.2 hectares, while for the former study it was 2.14 hectares (1.82 for highlands and 3.23 for coastal plain). The national average size for subfamily farms was 1.86 hectares. The sample by Manger-Cats seems to be more representative of the actual farm size of this sector. Therefore, with the difference in size of farms in the two studies taken into account, the lower figure given in the IDESAC study is probably not inconsistent with the Manger-Cats estimate. For purposes of this study, the per family income for the traditional sector will be assumed to be equal to approximately Q500.00.

The traditional sector will be assumed homogenous with respect to the marginal propensity to consume (i.e., marginal propensity to consume will be assumed constant for all levels of income in the traditional sector).

The Commercial Agriculture Sector

The commercial agriculture sector will be divided into three subsectors by farm size or income strata. These three subsectors are: (1) family size farms, 7.1 - 45 hectares; (2) small multi-family farms, 45.1 - 896 hectares, and (3) large multi-family farms, greater than 896 hectares. Average per-family income will be assumed to be Q1600.00, Q9700.00, and Q29,000 for each group, respectively.[3] Also to be included in the income of this sector, will be income derived from "produccion pecuaria" which includes such products as eggs, milk, wool, honey, and bee's wax. Also, income from cattle and other animals will be included. Because of lack of data on the income distribution of these activities, we will simply assume that income is distributed from these activities in the same proportion as the income from crops. While it is more difficult to locate this sector geographically, it is safe to say that most of the large farms producing export crops are located in the coffee piedmont and south coastal regions.

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[3]These estimates are consistent with the study by Manger-Cats.

The Nonagricultural Sector

The nonagricultural sector will be defined as all nonagricultural sectors of the economy including government and services. This sector will be divided into ten income strata in accordance with the urban budget study referred to earlier [Orellana, 1972].

There are three important interactions which take place among these three sectors of the model: (1) seasonal movements of labor from the traditional sector (mainly the western highlands) to the large commercial farms, in the coffee piedmont or south coastal plains, (2) mutual demand for goods produced by each sector, and (3) interregional flows of savings.

Each year more than 200,000 cultivators of small plots supplement their incomes by working on the large farms on a seasonal basis [Schmid, 1968]. In addition to the seasonal workers, are the permanent workers which are the workers without land and the "mozos colonos." Mozos colonos are permanent workers on the large fincas who have been given small plots of land to work for themselves in addition to working the large finca. Both of these latter groups are included in the traditional sector.

According to Schmid, there is some complementarity between employment in the subsistence sector and in the commercial agriculture sector, especially for the coffee harvest. By complementarity, it is meant that the seasonal demand for workers by the commercial sector does not conflict with planting or harvesting periods in the traditional sector.

According to Schmid, if the average migratory worker has only one hectare of land at his disposal, which was the case in his study, he works about 52 days on his home farm. This would leave about 300 days per year available for non-farm employment. The workers interviewed in his study worked an average of 101 days on the large farms. This would appear to leave workers with 150 days for which they do not take employment. If this conclusion is correct and if workers are willing to work for longer periods of time at the set wage rate, then as assumption of a perfectly elastic supply of labor (at least over a wide range) in this market seems justified. To quote Schmid:

> ... to the extent that the hiring of labor from the subsistence farms takes place during the slack season on the farms, the supply of labor, in Guatemala can be considered to be unlimited.

This assumption will be employed in the model.

The mutual demand relationships and interregional flows of savings are of central importance to this study because the distribution of income is both affected by and in turn affects these variables.

Unfortunately, no data exists for these relationships but it is hoped that the model and results to follow will shed some light on these relationships.

The Model

A dynamic three sector linear programming model is presented which allows the investigation of the effects of land reform, and/or a redistribution of income upon important economic variables is presented. The three sectors are: (a) traditional agriculture, (b) commercial agriculture, and (c) nonagriculture. The model assumes five time periods where each time period lasts two years. Therefore, the model spans a ten year time horizon.

Some important characteristics of the model are: (a) Consumption functions are specified by sector, type of good (food or nonfood), and income level. (b) The traditional sector has a choice of three different technologies. Each technology represents higher income per hectare of land and also requires more credit or savings in order to purchase the package of inputs associated with each technology. (c) Capital is a binding constraint in the commercial agriculture and nonagriculture sectors. Land is a binding constraint in the traditional sector, although the constraints can be relaxed by technological change (i.e., putting more land under production with a higher level of technology). However, since additional savings and credit is required to implement a more advanced technological package, savings and credit can ultimately be a binding constraint for the traditional sector. (d) Labor is assumed not to be a binding constraint. (e) Investment in the commercial agriculture or nonagricultural sectors in time period t will increase capacity of those sectors in time period t+1. (f) Intersectoral flows of saving can take place and savings are to be allocated optimally. The total volume of savings to be allocated will be the sum of private savings, government savings, and net inflow of foreign capital. Savings and investment are allocated in such a way as to maximize income while satisfying demand and capacity constraints. Allocation of investment and savings not only depends upon the return to investment in the sectors, but also depends upon demand for the products produced by the sectors. Changing the distribution of income effects the total amount of savings available for investment, the total demand for consumption goods, and the composition of consumption demand (at least between food and nonfood goods).

The objective function to be maximized is given by the following expression:

$$W = \sum_{t=1}^{5} \delta_{Tt}(1+\rho)^{-t} Y_{Tt} + \sum_{t=1}^{5} \delta_{Rt}(1+\rho)^{-t} Y_{Rt} + \alpha_A I_A^{5} + \alpha_N I_N^{5}$$

where:

Y_{Tt} - income in the traditional sector in time period t

Y_{Rt} - the sum of income in the commercial agriculture and nonagricultural sectors in time period t

δ_{it} - increment to welfare resulting from a one unit increase in income for sector i in time period t.[1] i = T,R

ρ - the time rate of discount

I_i^5 - the value of gross investment in the last time period i = A,N

α_i - the increment to welfare resulting from a one unit increase in investment in the commercial agriculture or nonagricultural sectors, respectively.

The reason for putting the last two terms into the objective function is to avoid "horizon effects" which may result due to the fact that investment in the last time period increases capacity in the next time period, which doesn't exist for the model. Therefore, in the obsence of these last two terms, the optimal value of investment in the last time period would be zero.

If the objective is to maximize the discounted present value of GDP, $\delta_{it} = 1$, i = T,R. Otherwise, let $\delta_{Tt} + \delta_{Rt} = 1$. Optimizing the model for various values of δ_{it} will simulate different policy emphases on the traditional sector vis-a-vis the rest of the economy. Examining the resulting solutions to the model should give insights to the trade-offs, in terms of sectoral incomes of reallocating savings to one sector at the expense of the other sectors.

The programming model used can be expressed in the following summary form:

Maximize $W = C'Y$ subject to

$$AY \leq \overline{X}$$

$$Y \geq 0$$

where:

C = 1 x n row vector of objective constants

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[1]Since it is impossible to determine a welfare function for society, it becomes the implicit welfare function of the people who hold power, and the weights are determined by their preferences.

Y = n x 1 vector of endogenous variables defined for the model

$\overline{X}$ = m x 1 vector of constants corresponding to the values of the exogenous variables and autonomous components in the model

A = m x n matrix of constant coefficients corresponding to the parameters of the model.

The variables and parameters specified separately for each region are defined as follows:

Endogenous Variables

Y_{it} = total income for sector i (t will denote time period t=1, 2...5) i = T,A,N

where

T = traditional sector

A = commercial agriculture sector

N = nonagriculture sector

Y^P_{it} = total production in sector i

Y^A_{Tt} = total income received from the commercial agriculture sector by agricultural laborers in the traditional sector

Y^N_{Tt} = total income received by the traditional sector from nonagricultural sources

L_{Tt} = total number of man days of agricultural labor required by the commercial agriculture sector

C^j_{it} = total demand of sector j for commodities of type i

C^N_{RNt} = portion of expenditures on food by the nonagricultural sector which goes to the nonagricultural sector itself

C_{At} = total consumption demand for agricultural goods produced by the commercial agricultural sector

C_{Nt} = total consumption demand for nonagricultural goods

C^i_{gt} = government consumption of goods and services from sectors i

M_{At} = imports of agricultural commodities

M_{Nt} = imports of nonagricultural consumer goods

I^i_{mt} = imports of investment goods by sector i

y_{it} = personal disposable income of sector i

C^i_{Rt} = total consumption demand by the ith sector for food

I_t = total investment demand

I^j_{it} = total investment demand by sector j for investment goods produced in the ith sector

T_{nt} = total net tax revenue

T^I_{it} = total net indirect taxes collected from sector i

T^D_{it} = total net direct taxes collected from sector i

S_{gt} = total government savings

S^i_{gt} = total government savings allocated to sector i

$(f_{it} - f'_{it})$ = net flow of savings to sector i

T_{kt} = proportion of land in traditional sector under technology k, k = 0,1,2

Exogenous or Predetermined Variables

Z_t = total amount of land available to the traditional sector

$\overline{X}_{it}$ = exports of goods and services from sector i

$\overline{T}^r_{it}$ = net government transfer to sector i

$\overline{F}_t$ = net inflow of foreign capital

$\overline{Q}^i_{t-1}$ = capacity output in period t-1 of sector i

Parameters

w = average wage rate paid to agricultural laborers working in the commercial agriculture sector per man day

e_1 = number of man days of agricultural labor (unskilled) required to produce one dollar (in constant dollars) of output in the traditional sector

e_2 = proportion of total income in the traditional sector which comes from nonagricultural sources

$\alpha^i_{R\ell}$ = autonomous consumption expenditures on food by the ℓth income group of the ith sector

$c^i_{R\ell}$ = marginal propensity to consume food by the ℓth income group in the ith sector

$\alpha^i_{N\ell}$ = autonomous consumption expenditures on nonfood goods and services by the ℓth income group of the ith sector

$c^i_{N\ell}$ = marginal propensity to consume nonfood goods and services by the ℓth income group of the ith sector

$\lambda_{i\ell}$ = proportion of total income of sector i which is in the income level ℓ

α = proportion of total expenditures on food by the nonagricultural sector which accrues to the nonagriculture sector itself

m_A = proportion of agricultural goods consumed which are imported

m_N = proportion of nonagricultural consumption goods which are imported

m_I = proportion of investment goods which are imported

t^I = average indirect tax rate

t^D = average direct tax rate

γ_i = incremental output-capital ratio for sector i i = A,N

P_k = yield per hectare in the traditional sector under technology k, k = 0,1,2

CD_k = working capital required to employ technology k on one hectare of land in the traditional sector in time period t.

The Equations

Total income for the traditional sector is the sum of income received from agricultural production, from agricultural labor in the commercial agricultural sector, and from nonagricultural activities.

$$Y_{Tt} = Y^{P}_{Tt} + Y^{A}_{Tt} + Y^{N}_{Tt} \qquad [1]$$

Income from working as an agricultural laborer is given by Equation 2 where w is the average wage rate per man day worked on a commercial farm.

$$Y^{A}_{Tt} = w\ L_{Tt} \qquad [2]$$

The total number of man days worked, L_T, is assumed to be a function of production in the commercial agricultural sector and is given by Equation 3 where e_1 is the man days required to produce one dollar of output (in constant dollars).

$$L_{Tt} = e_1\ Y^{P}_{At} \qquad [3]$$

Equation 2 implies a perfectly elastic supply of labor from the traditional sector to the commercial agriculture sector. This assumption is consistent with the concept of a seasonal labor surplus where the peak demand for labor on the traditional farms does not coincide with the peak demand for labor on the commercial farms.

Income received from the nonagricultural sector is assumed to be a certain fraction of total income for the traditional sector. This relationship, given in Equation 4, is not intended to be a behavioral function, but merely an accounting mechanism to account for the fact that a certain percentage of the income of traditional farmers comes from nonagricultural sources. To the extent that these traditional farmers spend their income differently than their urban counterparts at the same level of income, this relationship will make a difference. Otherwise, this income could be left in the nonagriculture sector and there would be no net effect on total aggregate demand.

$$Y^{N}_{Tt} = e_2\ Y_{Tt} \qquad [4]$$

Equations 5 and 6 are accounting relationship to account for the transfer of income from the commercial agriculture and nonagricultural sectors, respectively, resulting from the activities discussed above.

$$Y_{At} = Y^{P}_{At} - Y^{A}_{Tt} \qquad [5]$$

$$Y_{Nt} = Y^{P}_{Nt} - Y^{N}_{Tt} \qquad [6]$$

We will now assume that actual output in the three sectors is equal to total demand. This is expressed by Equation 7.

$$Y^{Pj}_{it} = \sum_j C^j_{it} + C^i_{gt} + \sum_j I^j_{it} + X_{it} - M_{it} - \sum_j I^j_{mt} \qquad [7]$$

$$i = T,A,N$$

$$j = T,A,N$$

Note: When i = N, we add one additional component of demand C^N_{RNt}. This accounts for the nonagricultural component of food demand by the urban sector. This component of demand is discussed below.

Changes in the distribution of income will have their primary effect on consumption (assuming differences in the MPC between income levels or sectors). Therefore, the following consumption functions, given below, are critical to the analysis. These are given by Equations 8 and 9. ℓ, in each sector, designates the income strata of each sector. To obtain the consumption function for the entire sector, the consumption functions for the various income stratum are summed over ℓ. $\lambda_{i\ell}$ is the proportion of total sectoral income found in the ℓth income strata of sector i, i.e., $\lambda_{i\ell} = \frac{Y_{i\ell t}}{Y_{jt}}$. Therefore, the vector $\lambda_i = (\lambda_{i1}\ \lambda_{i2} \cdots \lambda_{in})$ reflects the distribution of income in sector i. Assuming the distribution of the population fixed, changing the $\lambda_{i\ell}$'s will be equivalent to assuming a different income distribution. It is through changing the parameters, $\lambda_{i\ell}$, that changes in intrasectoral distribution of income are simulated.

The consumption equations are given below.

$$C^j_{it} = \sum_\ell a^j_{i\ell t}\lambda_{j\ell} + \sum_\ell c^j_{i\ell t}\lambda_{j\ell} y_{jt} \qquad [8]$$

$$i = R,N$$

$$j = T,A,N$$

Demand for food is allocated between the two agricultural sectors by the following equations.

$$C^T_{Rt} = C^T_{Tt} + C^T_{At} \qquad [9]$$

$$C^N_{Rt} = C^N_{Tt} + C^N_{At} \qquad [10]$$

$$C^A_{Rt} = C^A_{At} \qquad [11]$$

Equation 9 implies that the traditional sector can augment its demand for food by purchasing food from the commercial agricultural sector. Equation 10 implies that the demand for food by the nonagricultural sector can be satisfied by the traditional agricultural or commercial agricultural sectors. Equation 11 implies that the commercial agricultural sector is self-sufficient. Another problem which must be dealt with is the problem of translating final demand for agricultural products, which is measured in terms of consumer's prices, into final demand measured at producer's prices. The trade margin is assigned to the nonagricultural sector and is included in C^N_{RNt}, which also includes such activities as processing of food. Value added by food processing or similar activities and trade margins will be assigned to the respective agricultural sector from which the demand for food originated. In the case of the traditional sector, this is realistic in that the producer (or his family) markets his own produce in the local market or is consumed directly by the family. In the case of the commercial agricultural sector, the assumption implies that value added to agricultural products, if not kept within the same family, is at least kept within the sector itself. Equation 12 expresses the portion of final demand for food which goes to the nonagricultural sector as a constant proportion of total demand for food $\overline{C}^N_R$.

$$C^N_{RNt} = \alpha \overline{C}^N_{Rt} \qquad [12]$$

Therefore, we have for urban demand for products produced by the agriculture sector at approximate producer prices the following relation.

$$C^N_{Rt} = \overline{C}^N_{Rt} - C^N_{RNt} \qquad [13]$$

Disposable income is given by Equation 12.

$$y_{it} = Y_{it} - T^I_{it} - T^D_{it} + \overline{T}^r_{it} \qquad [14]$$

Total government consumption expenditures is assumed to be a function of GDP. Also, it is assumed that government consumption demand is satisfied by the nonagricultural sector so that

$$\sum_i C^i_{gt} = C^N_{gt} = g(Y_{Tt} + Y_{At} + Y_{Nt}). \qquad [15]$$

Total investment demand is the sum of investment in the three sectors. This is given by Equation 16.

$$I_t = \sum_j I^j_{Nt} \qquad j = T,A,N \qquad [16]$$

The demand for imports is assumed to be a constant proportion of consumption and investment expenditures. Further, we will assume that the proportion of total demand for a good that is satisfied by imports depends on the type of good. We distinguish between three types of goods: (1) agricultural goods, (2) nonagricultural consumer goods, and (3) investment goods.

Assuming that imports of food do not compete with products produced by the traditional sector (i.e., $M_T = 0$), let

$$C_{At} = \sum_j C^j_{At} \qquad j = T,A,N \qquad [17]$$

so that

$$M_{At} = m_A C_{At}. \qquad [18]$$

Let total consumption of nonagricultural goods be given by

$$C_{Nt} = \sum_j C^j_{Nt} + C^N_{RNt} \qquad j = T,A,N \qquad [19]$$

so that

$$M_{Nt} = m_{Nt} C_{Nt}. \qquad [20]$$

The import functions for investment goods is given by Equation 21.

$$I^i_{mt} = m_I I_{it} \qquad i = T,A,N \qquad [21]$$

Indirect taxes and direct taxes are assumed to be proportional to gross income. Indirect and direct tax functions are given by Equations 22 and 21, respectively.

$$T^I_{it} = t^I Y_{it} \qquad i = T,A,N \qquad [22]$$

$$T^D_{it} = t^D Y_{it} \qquad i = T,A,N \qquad [23]$$

The following identities express total net taxes and government savings, respectively.

$$T_{nt} = \sum_i [T^I_{it} + T^D_{it} - T^r_{it}] \qquad i = T,A,N \qquad [24]$$

$$S_{gt} = T_{nt} - \sum_i C^i_{gt} \qquad i = T,A,N \qquad [23]$$

Private savings by sector are defined by the following expressions.

$$S^P_{it} = y_{it} - \sum_j C^{i\,a}_{jt} \qquad i = T,A,N \qquad [25]$$

The programming model allocates total government savings among the three sectors. Therefore, let

$$\sum_i S^i_{gt} = S_{gt} \qquad i = T,A,N \qquad [26]$$

Total gross production in the commercial agriculture and non-agricultural sectors is less than or equal to capacity in each sector. Capacity will be determined by the capacity of the previous period plus any addition to capacity resulting from investment in the previous period. The increase in capacity resulting from investment will be equal to the incremental output-capital ratio for each sector multiplied by the total amount of gross investment that takes place in that sector. This relationship is expressed by the following inequality.

$$Y^P_{it} \leq \overline{Q}^i_{t-1} + \gamma_i I_{i\,t-1} \qquad i = A,N \qquad [27]$$

It will be assumed that the traditional agricultural sector has available to it, three alternative technologies. All available land or a portion of the total available land can be farmed under technology k. Output in the traditional sector is less than or equal to capacity, Y^{PC}_{Tt}, which depends on the total land available, Z_t, the yield per acre under technology k, P^k_t, and the proportion of land under technology k, T_k. These relationships are expressed in Equations 28 and 29.

$$Y^P_{Tt} \leq Y^{PC}_{Tt} \qquad [28]$$

$$Y^{PC}_{Tt} = \sum_k P_{kt}\, T_{kt}\, Z_t \qquad [29]$$

where

$$\sum_k T_{kt} = 1$$

and

$$P_{0t} < P_{1t} < P_{2t}.$$

---

[a]Equation 25 is slightly modified for S^P_{Nt}, in that an additional term, C^N_{RNt}, is substracted from disposable income, y_{Nt}.

Equation 29 implies that capacity in the traditional sector can be increased by increasing the total amount of land available, as in a land reform or by allocating more land to a higher level of technology. It will be further assumed that once a technology is adopted, it will not be replaced by a lower level of technology. In other words, assuming the available land is constant

$$Y^{PC}_{Tt+1} \geq Y^{PC}_{Tt}.$$

It is assumed that the fixed capital stock is neglible in the traditional sector. However, in order to employ a certain level of technology a certain level of working capital is required to purchase intermediate inputs or improved seed. Working capital will come from savings and credit. Therefore, "investment," I^T_t, in the traditional sector, will be interpreted as working capital.

Let

$$I^T_t = \sum_k CD_{kt}\, T_{kt}\, Z_t \qquad [30]$$

where

CD_{kt} = working capital required to employ technology k on one hectare of land in time period t.

It is assumed that higher levels of technology require more working capital.

There are three sources of savings for the economy as a whole. These are: (a) private savings expressed by Equation 25, (b) public savings given by 23, and (c) net foreign flows of capital, $\bar{F}$. For a particular sector, the sources of savings are private savings generated within the sector itself, public savings that are allocated to that sector, and net inflows of savings from the other sectors.

Investment in each sector must be less than or equal to the total amount of savings available for that sector. Inequality 31 expresses this relationship.

$$S^P_{it} + S^i_{gt} + (f_{it} - f'_{it}) \geq I_{it} \qquad i = T,A,N \qquad [31]$$

The term, $f_{it} - f'_{it}$, found in the investment constraint, requires additional explanation. These terms are important because they allow intersectoral flows of savings. For example, $(f_{Tt} - f'_{Tt})$ is positive, then the net flow of savings to the traditional sector is positive. Likewise, if the term is negative, savings are flowing out of the sector to the rest of the economy.

The sum of the flows of savings to the various sectors must be equal to zero, plus the net inflow of foreign capital. This constraint is given by Equation 32.

$$\sum_i (f_{it} - f'_{it})^a = \overline{F}_t \qquad i = T,A,N \qquad [32]$$

Total imports must be less than or equal to the amount of foreign exchange earned by exports, plus the net inflow of foreign capital F. This is expressed by 33.

$$\sum_i (M_{it} + I^i_{mt}) \leq \overline{F}_t + \sum_i \overline{X}_{it} \qquad i = A,N \qquad [33]$$

Foreign capital, $\overline{F}$, and exports, $\overline{X}_A + \overline{X}_N$, are assumed to be exogenously determined and not determined within the model.

Since the sum of excess sectoral demands must be equal to zero, the following equation must hold.

$$\sum_i Y^P_{it} = \sum_j \sum_i C^j_{it} + C^N_{RNt} + \sum_i C^i_{gt} + \sum_i I_{it} + \sum X_{it} - \sum_i M_{it} - \sum_i I^i_{mt}$$

$$i = T,A,N \qquad j = T,A,N \qquad [34]$$

This forces total savings (private, public and foreign) to equal total investment, which is an accounting identity.

The model allocates savings and investment among the various sectors in a way that maximizes the objective function subject to the total level of savings, which comes from abroad, or is generated by savings behavior and taxation policy within the country itself. Because the marginal propensities to consume are different for each sector and for each level of income within a sector, a change in the distribution of income will affect both the total level of savings and the level of savings generated within each sector. This, in turn, will affect both total funds available for investment and the intersectoral flows of savings required to satisfy investment requirements in each sector, resulting from changes in demand for goods produced by each sector. Therefore, a redistribution of income, which will change both the total amount and the composition of consumption demand, will also affect both total investment requirements and sectoral investment requirements. The model, therefore, captures both the savings and demand effects of a redistribution of income simultaneously.

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[a]The use of $(f_{Tt} - f'_{Tt})$, instead of a composite variable say, f_{Tt}, which could be either negative of positive, is due to the nonnegativity constraint imposed by the linear programming model. Therefore, when the net flow of savings to a sector is negative, the program will choose a positive value of f'_i, and f_i will not enter the optimal basis, making $(f_{it} - f'_{it})$ negative. f_{it} and f'_{it} will never enter a basis together because each is a linear combination of the other.

Assumptions and Estimation of Parameters

In order to account for conditions and data limitations specific to Guatemala, the following assumptions are made [Applegate, 1973].

1. The traditional sector does not export any of its output to the rest of the world (i.e., $X_T = 0$).
2. Imports of agricultural goods are assumed to be competing with output produced by the commercial agriculture sector only and not that of the traditional sector (i.e., $M_T = 0$).
3. All investment goods are produced by the nonagricultural sector (i.e., $I_T^j = I_A^j = 0$, $j = T,A,N$).
4. National account data does not break government consumption expenditures into its components. Therefore, there is no way to allocate this demand among the three sectors. Since a large portion of government consumption expenditures is for the purchase of services, it is assumed that total government consumption demand goes to the nonagricultural sector (i.e., $C_g^T = C_g^A = 0$).
5. The traditional sector pays no direct taxes (i.e., $T_{Tt}^D = 0$).

Before beginning the discussion of the estimation of the parameters of the model, a note regarding the general nature of the problem of estimating the parameters of this particular model seems in order. The data requirements of the model call for fairly disaggregated data in time series form. In general, this data does not exist in Guatemala. The parameters were estimated using such sources as cross section budget studies for consumption parameters and results of studies done by other people using sample data. The basic problem was to find reasonable estimates for the parameters which are not only reasonable from a "micro" standpoint, but when applied in the model, result in estimates of values of the variables, when aggregated together, are consistent with national income account data. It was impossible to use two stage least squares or other simultaneous estimation techniques using data, which is consistent with national income data to begin with and derive estimates of the parameters which would assure that the model be reasonably consistent with the national account data. However, it was possible to derive estimates of the parameters of the model, which result in the model giving results which are reasonably in line with the official national account data.

Production and Capital Requirement Coefficients for the Traditional Agriculture Sector

The yield per hectare for technology k, P_k, and the working capital required to employ technology k on one hectare of land, CD_k, are calculated from data provided by Johnston in his study of small farmer agriculture in the Guatemalan highlands [Johnston, 1974]. Three levels of technology are defined: (1) k = 0. This is the lowest level of technology, which is the traditional or present day lower technology characterized by low use of agricultural chemicals, (2) k = 1. This is a present day intermediate technology in which farmers use some fertilizer but little else, (3) k = 2. This is a present day high technology in which farmers use more fertilizers, increase their planting density, and use insecticides, herbicides and fungicides as recommended by extension agents and others. This level of technology is used on most demonstration plots.

The above technology levels are defined by Johnston for corn, milpa (combination of corn, squash, and beans), and wheat activities. Other technologies are defined which are applicable to potato and other vegetable production. These other technologies were ignored, however, because a small portion of agricultural production in the Guatemalan highlands is potato and vegetable production. This leads us to the important problem of aggregation. The model treats the traditional sector (as well as the other sectors) as if one homogenous good is produced by that sector. If the yield per hectare (in value terms assuming constant prices) for all crops were the same, there would be no problem in obtaining the aggregate yield per hectare for the traditional sector as a whole. Unfortunately, this is not the case, because yields not only differ between crops but vary according to the type of land. Adding to the problem, is that Johnston associates technological levels with the type of crop and the type of land. For example, the highest level of technology is applied to crops grown on valley land. The model treats land as homogeneous and, therefore, does not distinguish between types of land. The explicit assumption of the model is that technological change allows a greater proportion of land in the traditional sector to be utilized under a higher level of technology, which implies that hilly land can be transformed into valley land. To the extent that valley land is limited, the model will overestimate the impact of technological change on the traditional sector. A further extension of the model will be to distinguish between types of land and also the type of crop.

To obtain the production coefficients from the data available, the following procedure was used. Johnston defines the production activities associated with each technological level and specifies a net yield (return) per hectare for each activity. The aggretate yield for a technological level is found by taking a weighted average of yields of the activities associated with a given technology. Table 5 shows the activities and corresponding yields under each

technology. Johnston ran many solutions which assume different resource endowments, which supposedly represent the range of possible "types" of farmers in the Guatemalan highlands. If we make the crude assumption that these "types" of farmers are equally distributed in the traditional sector, the proportion of land in each crop activity can be found by taking the average of total land under each crop activity for all of the Johnston solutions. These average proportions provide us with the weights we are seeking.

TABLE 5

Crop	Activity[a]	Technology Required k	Return to Land, Labor and Savings per Hectare[b]
milpa	MH1	0	88.45
milpa	MH2	0	124.60
milpa	MV1	0	112.01
corn alone	CV2	0	66.59
wheat	WHV1	0	83.65
wheat	WHV2	0	84.35
milpa	MV2	1	163.44
corn alone	CV3	1	88.43
wheat	WV3	1	141.69
milpa	MV3	2	216.05
corn alone	CV4	2	247.98
wheat	WV4	2	186.15

Source: Johnston (1974)

[a]Crop activities are identified by crop, by type of land they require, and by the relative amount of working capital they require according to the following code: M = milpa; C = corn alone; W = wheat; P = potatoes; H = hilly land; V = valley land; HV = a combination of hilly and valley land; 1 = very little working capital; 2 = an intermediate amount of working capital; 3 = a high amount of working capital; 4 = a very high amoun of working capital.

[b]This is a net return. It is calculated by multiplying the yield per ha for each crop by its average price and subtracting out the value of inputs, plus depreciation on fixed capital required to produce one hectare of that crop.

Table 6 shows the activities entering the Johnston solutions at each level of technology, along with the corresponding weight. (Note that given a certain level of technology does not necessarily mean that activities requiring lower levels of technology are excluded. For example, MH2 appears in solutions when technology level 2 is allowed, even though it only requires technology 0). Each crop activity requires a different level of working capital so that the capital requirement coefficients for each technological level are

calculated identically as the production coefficients using the same set of weights. Table 7 shows the production coefficients, P_k,

TABLE 6

Weights Assigned to Crop Activities
Grown Under Each Level of Technology

Technology Level 0

Activity	Weight
MHV2	.4165
MH2	.2064
MV1	.3315
CV2	.0451

Technology Level 1

Activity	Weight
WV3	.4101
MV2	.1672
MH2	.4146
MH1	.0081

Technology Level 2

Activity	Weight
CV4	.51
MV3	.046
MV2	.062
MH2	.382

and the capital requirement coefficients, CD_k, for each level of technology.

TABLE 7

Level of Technology

k	P_k	CD_k
0	101.02	58.58
1	137.81	81.93
2	194.07	107.58

The Consumption Functions

Data, to estimate the consumption functions, was obtained from two budget studies carried out by the Instituto de Investigaciones Economicas Y Sociales (IIES) at the University of San Carlos in Guatemala City. During September 1966 to January 1967, a rural budget study was carried out which had a sample size of 1759 families and consisted of families where the head was defined as an agricultural worker [Orellana, 1966]. The study included rural families with incomes from $100 to $3000 per annum. In 1969, a more extensive budget study, in that the sample size was larger and the sampling techniques improved, was carried out by the same institute, which included urban families from the five largest cities of Guatemala, Guatemala City, Quezaltenango, Puerto Barrios, Jutiapa, and Esquintla [Orellana, 1972]. The study included urban families with incomes that ranged from $100 to more than $10000 per year.

It was felt that using both of the studies would give a representative sample of people at all levels of income, as well as the rural and urban components of the population.

The basic methodology used to estimate the parameters of the consumption functions by sector and level of income is as follows. It was assumed that income in the traditional sector and the bottom sector (family size farms) of the commercial agriculture sector was spent as rural income. Income from the rest of the commercial agricultural sector and the nonagricultural sector was assumed to be spent as urban income. Therefore, the rural and urban budget studies were used to estimate consumption functions for these two basic groups. The budget studies give family consumption expenditures and average income for 23 and 20 income groups for the rural and urban studies, respectively. Consumption functions for food and nonfood were estimated using income and consumption data at different levels of income, giving 23 observations for the rural functions and 20 observations for the urban functions. The consumption functions fit were of the form $C = a + by + cy^2$. Since the marginal propensity to consume is given by $b + 2cy$, the sufficient condition for a falling marginal propensity to consume as income rises is that c be negative. However, since the model is linear, it was necessary to express the quadratic consumption function as a series of linear segments. This was done by dividing rural and urban income into income groups corresponding to the different levels of income specified for income distribution purposes. The marginal propensity to consume and intercept term was calculated at the mean income for that particular income group. This resulted in the estimates of $c^j_{i\ell}$ and $a^j_{i\ell}$ for all i, j and ℓ.

The original raw data for the budget studies was not available. The consumption and income data were in terms of group averages for each income level. This would not necessarily present a problem but, in this case, the number of observations in each group is different. Therefore, the model is of the form:

$$\bar{y} = \beta \bar{X} + \bar{U}$$

where:

$\bar{y}$ and $\bar{X}$ are group means of the dependent and independent variables, respectively.

$\bar{U}$ is the average error for each group.

Therefore, if $U \sim (0, I\sigma^2)$

then $\bar{U} \sim (0, V\sigma^2)$

where:

$$V = \begin{pmatrix} \frac{1}{n_1} & & & \\ & \frac{1}{n_2} & & \\ & & \ddots & \\ & & & \frac{1}{n_i} \end{pmatrix}.$$

When the n_i are not the same, heteroschedasticity results and ordinary least squares will result in biased estimates of the standard errors of the coefficients. To eliminate this problem, weighted least squares was used. The variables of the model were transformed by premultiplying by the following diagonal matrix:

$$\begin{pmatrix} \sqrt{n_1} & & & \\ & \sqrt{n_2} & & 0 \\ & & \ddots & \\ & 0 & & \sqrt{n_i} \end{pmatrix}.$$

The results of fitting the above polynomial, using the rural data for food and nonfood, respectively, are given below. The standard deviation of the estimate of a coefficient is given in parentheses below the coefficient. The t statistic is reported below the standard deviation.

For total consumption we have:

$$\begin{array}{lcccc} C = & 90.36 & + \; 0.9279\gamma & - \; 0.00014\gamma^2 \\ & (18.07) & (.0249) & (.000011) \\ & 7.68 & 19.52 & -6.40^{a} \end{array}$$

---

[a]Indicates the estimate is significantly different than zero at the 0.01 level.

For food we have:

$$C_R = 77.86 + .4863y - 0.000073y^2.$$

Since the same independent variable appears in both equations, the consumption of nonfood goods and services can be found by subtracting the values of the parameters of the consumption function for food from the respective parameters in the total consumption function. Therefore

$$C_N = 12.50 + 0.4416Y - 0.00013Y^2.$$

The results of fitting the polynominal consumption function for the urban data are presented below.

For total consumption we have:

$$\begin{array}{lll} C = 46.16 + & 1.0299Y - & 0.00002Y^2 \\ \quad (4.53) & (0.1182) & (0.000008) \\ \quad 10.18 & 8.71 & 2.29^1 \end{array}.$$

For food we have:

$$\begin{array}{lll} C_R = 278.49 + & 0.2673Y - & 0.00001Y^2 \\ \quad (50.27) & (0.0233) & (0.000001) \\ \quad 5.54 & 11.49 & -5.99^1 \end{array}.$$

Therefore, for nonfood we have:

$$C_N = 232.33 + 0.7626Y - 0.00001Y^2.$$

Since the coefficient, c, is significantly different from zero and negative in all cases, we reject the hypothesis that c is equal to zero and that the marginal propensity to consume is constant at all levels of income.

Table 8 presents the calculated marginal propensities to consume and corresponding intercepts by sectors and income groups within the sectors.

Deriving the marginal propensity to consume food and nonfood goods and services for the rural and urban populations and plotting these on the same graph indicates some interesting differences in consumption behavior between the rural and urban population, as well as between groups of people and different income levels. Comparison of rural and urban total marginal propensities to consume is presented in Figure 6. Comparison of rural and urban marginal propensities to consume food and nonfood at various levels of income is presented in Figure 7.

From Figure 6 it appears that the difference in consumption behavior between rural and urban people is, at least, as great as

TABLE 8

Average Income, Marginal Propensity to Consume and Autonomous Consumption Expenditure by Sector and Level of Income Within Each Sector for Food and Nonfood per Family[1]

Sector and Income Strata	$\bar{Y}$	MPC at $\bar{Y}$ Food	MPC at $\bar{Y}$ Nonfood	Intercept at $\bar{Y}$ Food	Intercept at $\bar{Y}$ Nonfood
Traditional sector	500.00	.4133	.3116	96.11	45.00
Commercial agriculture					
Family farms	1,600.00	.2527	.0256	264.74	345.30
Small multi-family	9,700.00	.0733	.5686	1,219.39	708.57
Large multi-family	30.00	0.01[a]	0.0[b]	2,064.72	14,306.64
Nonagricultural sector					
0 - 500	411.50	.2591	.7544	280.17	-230.65
501 - 1000	787.76	.2516	.7469	284.65	-226.17
1001 - 1500	1,249.07	.2424	.7377	293.99	-216.83
1501 - 2000	1,749.77	.2324	.7277	308.93	-201.88
2001 - 3000	2,441.62	.2185	.7138	338.03	-172.80
3001 - 4000	3,458.16	.1982	.6935	397.86	-112.96
4001 - 6000	4,833.14	.1707	.6660	511.78	0.96
6001 - 8000	6,828.66	.1308	.6261	744.29	233.48
8001 - 10000	8,788.73	.0916	.5869	1,047.25	539.43
10000 +	13,998.99	0.0[c]	.4827	2,064.72	1,726.27

[a]MPC = 0 at Y = 13,365
[b]MPC = 0 at Y = 38,130
[c]MPC = 0 at Y = 13,365

These represent per family autonomous consumption expenditures. To find the intercept for each level of income, the estimated number of families in each income level was multiplied by the above per family intercepts.

the difference in behavior between people at different levels of income. At any given level of income, the marginal propensity to consume is higher for urban people than for rural people. A glance at Figure 7 indicates that the difference in total marginal propensities to consume for the rural and urban population is mostly made up of the difference in the marginal propensity to consume nonagricultural goods.

[1]It should be noted that consumption data is not net of indirect taxes.

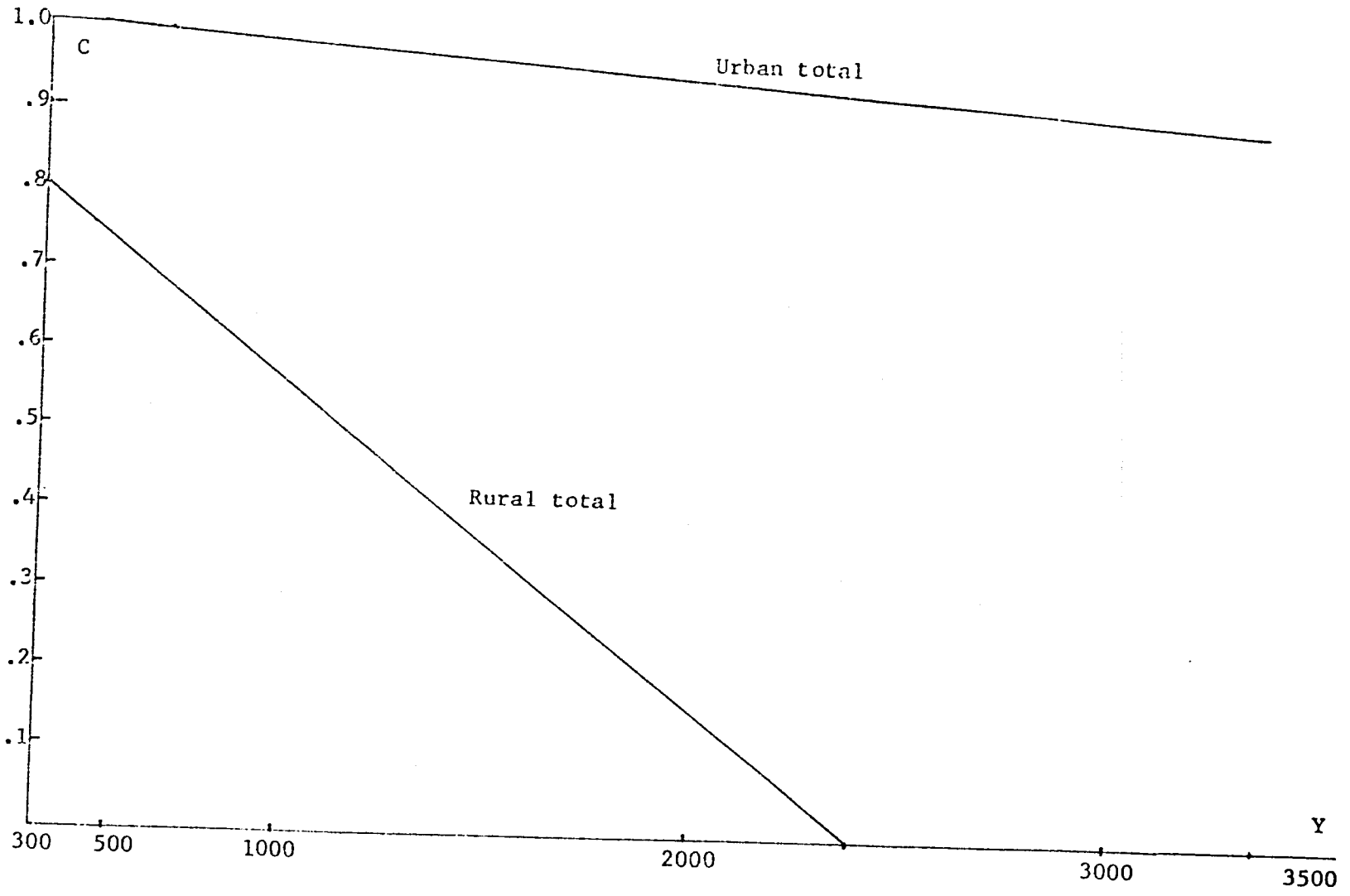


Figure 6. Comparison of Rural and Urban Marginal Propensities to Consume at Various Levels of Income

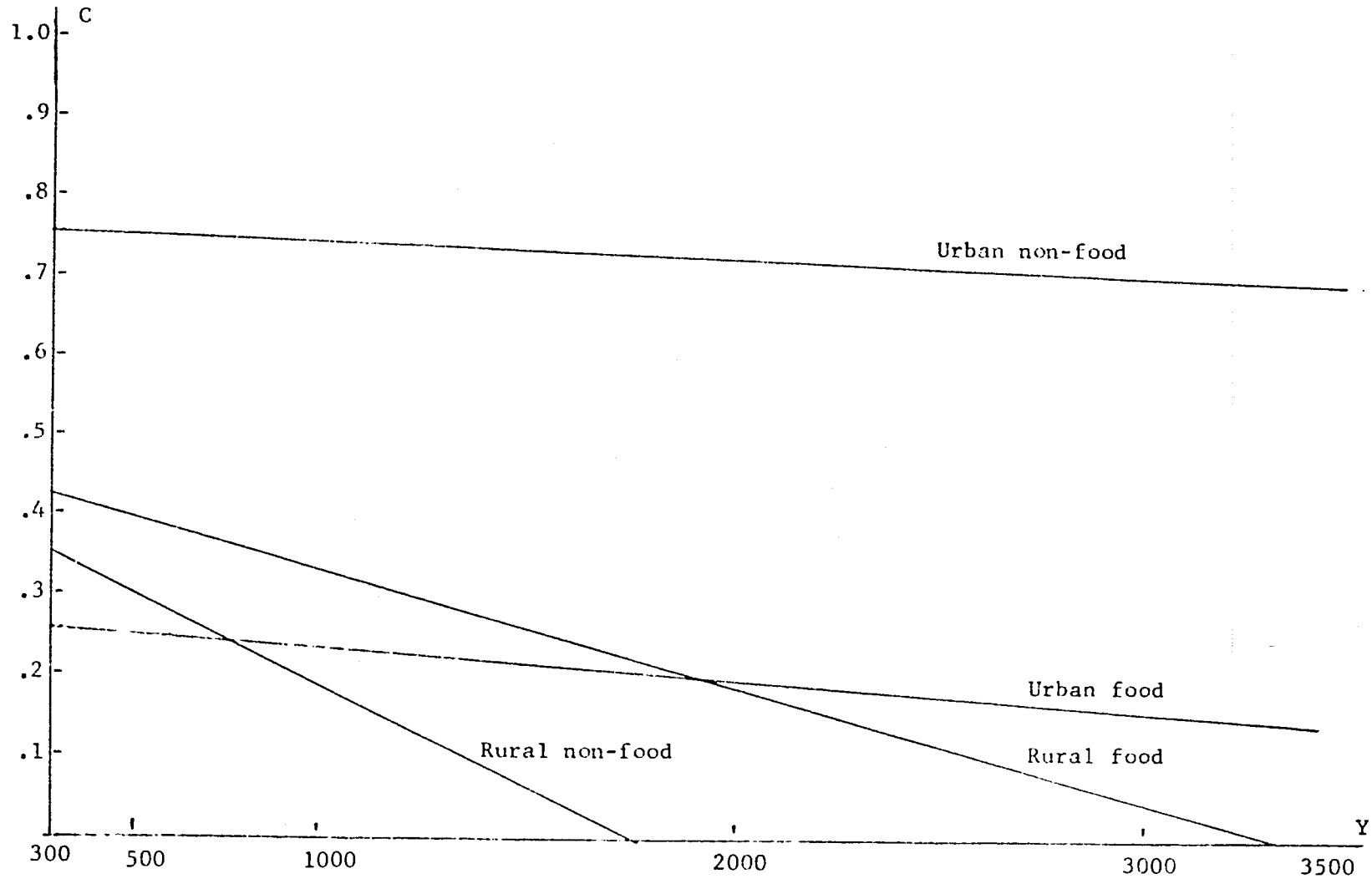


Figure 7. Comparison of Rural and Urban Marginal Propensities to Consume Food and Nonfood at Various Levels of Income

To provide a more rigorous test of the hypothesis that the urban marginal propensity to consume is greater than the rural marginal propensity to consume, the urban and rural data were pooled and dummy variables were added to test for a significant difference in b and c between rural and urban populations.

To test for a shift in the parameter, b, the following equation was fit using the pooled urban-rural data.

$$C = a + b\,Y + b'Y' + C\,Y^2$$

where:

$$Y' = 0 \text{ for urban observations}$$

$$y' = Y \text{ for rural observations}$$

If b' turns out to be significantly greater than zero, the null hypothesis, that the parameter, b, is not greater for rural income than for urban income, will be rejected. Similarly if b' is significantly less than zero, the null hypothesis, that the parameter, b, is not less for rural income than for urban income, will be rejected. The results of fitting the polynomial consumption function over the pooled rural and urban data are presented below.

a = 148.53	t = 3.53
b = 0.9905	t = 36.93
c = -0.2754	t = -4.97
d = -0.000017	t = -7.73

b' is significantly less than zero at the 0.001 level of significance with 16 degrees of freedom. We, therefore, reject the hypothesis that the parameter, b, is not less for rural income.

The same procedure was applied to test for a shift in the parameter, c, between urban and rural income. The following equation was fit.

$$C = a + b\,Y + c\,Y^2 + c'(Y^2)'$$

where:

$$(Y^2)' = 0 \text{ for urban observations}$$

$$(Y^2)' = Y^2 \text{ for rural observations.}$$

The results of fitting this equation are presented below.

a = 60.89	t = 1.82
b = 1.0224	t = 38.75
c = -0.000019	t = -8.64
d = -0.00016	t = -5.34

c' is significantly less than zero at the same level of significance leading to the rejection of the hypothesis, that the value of c is not less for rural than for urban income.

Since MPC = b Y + 2 c Y and b and c seem to be less for rural income, we conclude that the marginal propensity to consume is smaller for rural than for urban people at any given level of income.

There are factors which may help explain this result. One factor has to do with the structure of the rural sector itself. Approximately 88% of all farms in Guatemala were classified as subfamily size in 1964 [Direccion General de Estodistica, 1964]. The distribution of the population should correspond roughly to the distribution of farms. The largest share of this population is made up of highland Indians whose consumption behavior is determined, at least, partly by tradition. For example, Indian women in the highlands pretty much still wear their traditional costumes. Corn is still the staple as it has been for centuries. Sol Tax, in his classic study of a Guatemala Indian economy, "Penny Capitalism" [Tax, 1963], makes the observation that while among the Indians the richer Indians live better than the poor, the differences are "strictly limited -- i.e., in degree not proportional to wealth and always within the bounds of the culture." More specifically:

> ... variations among rich and poor (Indians) are held strictly within bounds. The richer families could certainly afford to plaster their adobe-brick house; they do not. They could afford windows which they do not have. They could have limemortar or even brick floors, but they do not. The could have raised fireplaces (as the Government demands), and do not. And so on. They lack such things not because they are unfamiliar with them - for Ladino homes they they frequent have them - but because they do not want them ... it is obvious that so-called "cultural factors," as opposed to economic, are involved.

Another factor, which may be contributing to the observed difference in consumption behavior between the urban and rural population, is related to the availability of goods and knowledge of new products. A look at any Guatemalan map with reasonable detail reveals literally hundreds of towns in the highlands with only a dirt path linking them to the outside world. A peasant who moves to the city is faced with a much greater variety of goods to purchase than perhaps would be found in his home market. The urban dweller is not only faced with a wider selection of goods, but his attitude toward purchasing them may change as a result of a "demonstration effect."

It was mentioned earlier, that income received by owners of multi-family size farms would be assumed to be consumed as urban income. This assumption seems consistent with the factors discussed above. These people have high mobility and many of them live in the

city much or all of the time. It seems reasonable to expect that their consumption habits would be better depicted by the urban consumption function rather than the rural consumption data, which was derived from interviewing mostly campesinos.

In order to estimate autonomous consumption expenditures by type of good and sector of demand, we need to know, in addition to the distribution parameters, $\lambda_{j\ell}$, the population of each income level for every point in time. This is required, because the consumption functions derived above are in per family terms. Table 9 presents estimates of the number of families by sector, income level, and time period. Given the estimates of autonomous per family consumption by income level found in Table 8, the following autonomous consumption parameters were derived.

Parameter Millions of 1976 $s	Time Period 1	2	3	4	5
$\sum_{\ell} \alpha_{R\ell}^{A} \lambda_{A\ell}$	66.13	68.98	71.16	73.35	75.60
$\sum_{\ell} \alpha_{R\ell}^{N} \lambda_{N\ell}$	318.03	333.46	349.65	366.73	384.35
$\sum_{\ell} \alpha_{N}^{T} \lambda_{T\ell}$	58.20	61.75	65.51	69.49	73.72
$\sum_{\ell} \alpha_{N}^{A} \lambda_{A\ell}$	79.21	82.44	85.33	88.20	91.11
$\sum_{\ell} \alpha_{N}^{M} \lambda_{N\ell}$	-66.96	-70.30	-73.68	-77.22	-81.14

TABLE 9

Number of Families in 1000s by Sector, Income Level, and Time Period

Sector	Time Period 1	2	3	4	5
Traditional	605.0	641.8	680.9	722.3	766.2
Commercial Agriculture	54.5	56.0	57.7	59.4	61.2
	9.3	9.9	10.2	10.5	10.8
	2.5	2.6	2.7	2.8	2.9
Nonagriculture	4.8	5.0	5.2	5.5	5.8
	50.8	53.3	55.9	58.6	61.5
	65.9	69.1	72.4	75.9	79.7
	55.9	58.6	61.5	64.5	67.6
	65.7	68.9	72.3	75.8	79.4

Sector	Time Period 1	2	3	4	5
Nonagriculture	43.2	45.3	47.5	49.8	52.2
	34.8	36.5	38.2	40.1	42.0
	13.3	14.0	14.7	15.4	16.1
	8.7	9.2	9.6	10.1	10.6
	9.4	9.8	10.3	10.8	11.3

Source: GAFICA

The Distribution Parameters, $\lambda_{i\ell}$

Data for calculation of the distribution parameters is presented below. It will be recalled that the traditional sector is treated as one income group. The commercial agriculture sector contains three income levels or classes, while the nonagriculture sector contains ten income levels or classes.

Income Level	Sector and Income Group	Average Income (per farm)	Number of Families (1000)	Total Income (1000000)	Distribution Parameter, $\lambda_{i\ell}$
0 - 800	Traditional	500.00[c]	605[a]	302.50	1.0
	Commercial Ag.				
801 - 2000	Family size	1600	54.5[a]	87.20	.3489
2001 - 15000	Small Multi-Family	9700	9.3[a]	90.21	.3610
15000 +	Large Multi-Family	29000	2.5[a]	72.50	.2901
	Nonagriculture[b]				
0 - 500	L_1	411.50	4.8	1.98	.0020
501 - 1000	L_2	787.76	50.8	40.02	.0401
1001 - 1500	L_3	1249.07	65.9	82.21	.0823
1501 - 2000	L_4	1749.77	55.9	97.81	.0979
2001 - 3000	L_5	2441.62	65.7	160.41	.1606
3001 - 4000	L_6	3458.16	43.2	149.39	.1496
4001 - 6000	L_7	4833.14	34.8	168.19	.1684
6001 - 8000	L_8	6828.66	13.3	90.82	.0909
8001 - 10000	L_9	8788.73	8.7	76.46	.0765
10000 +	L_{10}	13998.99	9.4	131.59	.1317

[a] GAFICA
[b] Orellana (1972)

The Incremental Output-Capital Ratios for the Commercial Agriculture and Nonagriculture Sectors

The incremental output-capital ratio, γ_i, for sector i is defined as the increment to output resulting from one unit of investment. It is different from the marginal product of capital in that the latter assumes other factors constant while the incremental output-capital ratio assumes that other factors may be increased along with capital, in accordance to least cost combination of resources. In mathematical terminology, $\frac{dQ}{dK}$ is the incremental output-capital ratio, while the marginal product of capital is given by the partial derivative rather than the total derivative or $\frac{\partial Q}{\partial K}$.

The incremental output-capital ratios for the commercial agriculture and nonagriculture sectors were estimated by fitting the following equations for each sector.

$$Y_t - Y_{t-1} = \gamma I_{t-1} \qquad i = 0,1,2,3$$

The equation was estimated with investment in the current year as the independent variable and also lagged one, two, and three years. Unfortunately, investment data, broken down into investment in agriculture and investment in nonagriculture, was only available for nine year, giving only eight degrees of freedom. On the basis of t tests and goodness of fit statistics, estimates of γ with investment in the current year were chosen. The estimated incremental output-capital ratios for the commercial agriculture and nonagricultural sectors are presented below with their standard errors and t values.

$$\hat{\gamma}_A = \underset{\substack{(.2612)\\ 2.9}}{0.747} \qquad \hat{\gamma}_N = \underset{\substack{(0.0398)\\ 12.0}}{0.4770}$$

$\hat{\gamma}_A$ is significantly different from zero at the 0.02 level of significance, while $\hat{\gamma}_N$ is significant at the 0.0001 level.

Estimates w, e, and e_2

The average wage rate, w, earned by agricultural laborers working in the commercial agriculture sector was estimated by Schmid for different plantation crops, coffee, sugar cane, and cotton [Schmid, 1968]. Taking the weighted average with the weights corresponding to the proportion of the unskilled labor force employed in the production of each crop, an average of Q0.88 per man day was determined.

e_1 is the number of man days required to produce one unit of output (measured in constant prices) in the commercial agricultural sector. Using data provided by Schmid, e_1, for export crops was estimated to be approximately 0.43 [Schmid,1968]. Using Table 3.5 of [Fletcher et.al., 1970], the proportion of export crops to total commercial production was estimated to be 0.57. It was assumed that $e_1 = 0$ for non-export crops, which implies that all seasonal laborers work only on fincas producing export crops. This, of course, is not completely accurate but it is true that the large fincas are almost exclusively export crop oriented, and it is these fincas which hire the great bulk of seasonal labor. This assumption, therefore, is probably not too extreme. At any rate, it should be recognized that L may be underestimated because of this factor. The final estimate of e_1 was taken to be the weighted sum of the value of e_1 for export and non-export crops. The weights were the proportion of export crops and non-export crops in total commercial agricultural production, respectively. The estimated value of e_1 is, therefore, taken to be 0.2438.

According to Gollas [Gollas, 1970], income from employment in nonagricultural activities makes up, on the average, about 28% of total income of the subsistence farmer. Therefore, e_2 was estimated to be equal to 0.28.

Estimate of α

α is the proportion of total expenditures on food by the nonagricultural sector which actually accrues to the nonagricultural sector itself. This measures value added by the nonagricultural sector as a proportion of the total value of agricultural production at final demand prices. A crude measure of α is given by taking the ratio of the difference between total agricultural production net of exports and the value of final consumption of food (domestic) and the value of final consumption of food. The estimates of α, for the years 1958-1966, ranged from 0.6320 to 0.6423. α was, therefore, assumed to have a constant value of 0.64.

Estimates of m_A, m_N, m_I

The import parameters were obtained from simple ratio estimates using national account data. Ordinary least squares regression was not used, because looking at the estimates for these parameters revealed that they changed over time but were fairly constant for several years at a time.

The estimates for the import parameters are given below.

$m_A = 0.03 \qquad m_N = 0.27 \qquad m_I = 0.40$

Estimates of t^I and t^D

The average indirect and direct tax rates were estimated using generalized least squares resulting in the following functions.

$$t^I = \underset{\substack{(0.0027)\\ 26.73}}{0.0727}\ Y \qquad R^2 = 0.9794,\ d = 1.72$$

$$t^D = \underset{\substack{(0.0024)\\ 8.45}}{0.0206}\ Y \qquad R^2 = 0.8361,\ d = 1.59$$

where:

t^I = total indirect taxes

t^D = total direct taxes

Y = gross domestic product.

Table 9 presents a summary of the parameters and their estimates.

TABLE 9

Summary of Parameters and Their Estimates

Parameter	Estimate
P_0	101.02
P_1	137.81
P_2	194.07
CD_0	58.58
CD_1	81.93
CD_2	107.58
$\sum_\ell \lambda_{T\ell} C^T_{R\ell}$	.4133
$\sum_\ell \lambda_{T\ell} C^T_{N\ell}$	.3116
$\sum_\ell \lambda_{A\ell} C^A_{N\ell}$	.2837

Parameter	Estimate
$\sum_{\ell} \lambda_{N\ell} C^{N}_{N\ell}$	.6564
$\sum_{\ell} \lambda_{A\ell} C^{A}_{R\ell}$	.1397
$\sum_{\ell} \lambda_{N\ell} C^{N}_{R\ell}$	.1632
λ_T	1.0
λ_{A1}	0.3489
λ_{A2}	0.3610
λ_{A3}	0.2901
λ_{N1}	0.0020
λ_{N2}	0.0401
λ_{N3}	0.0823
λ_{N4}	0.0979
λ_{N5}	0.1606
λ_{N6}	0.1496
λ_{N7}	0.1684
λ_{N8}	0.0909
λ_{N9}	0.0765
λ_{N10}	0.1317
γ_A	0.747
γ_N	0.477
w	0.88
e_1	0.24
e_2	0.28
α	0.64
M_A	0.03
M_N	0.27
M_I	0.40
t^I	0.07
t^D	0.02

Table 10 presents the values of the exogenous or autonomous components of the model, which make up the right hand side of the constraint equations.

TABLE 10

Values of Exogenous Components of the Model by Time Period in 1970 Prices

Variable	Time Period 1	2	3	4	5
X	720.62	771.07	825.04	882.29	944.59
X_A	377.28	395.01			
X_N	343.34	376.06			
$\sum_\ell \alpha_R^T \lambda_{T\ell}$	124.30	131.88	139.90	148.41	157.44
$\sum_\ell \alpha_R^A \lambda_{A\ell}$	66.13	68.98	71.16	73.35	75.60
$\sum_\ell \alpha_R^N \lambda_{N\ell}$	318.03	333.46	349.65	366.73	384.35
$\sum_\ell \alpha_N^T \lambda_{T\ell}$	58.20	61.75	65.51	69.49	73.72
$\sum_\ell \alpha_N^A \lambda_{A\ell}$	79.21	82.44	85.33	88.20	91.11
$\sum_\ell \alpha_N^N \lambda_{N\ell}$	-66.96	-70.30	-73.68	-77.22	-81.14
$Q_{T\ t-1}$	145.89				
$Q_{A\ t-1}$	923.50				
$Q_{N\ t-1}$	2840.90				

All other exogenous components were assumed to be equal to zero.

Empirical Results

The model was used to investigate the effects of wider spread adoption of more advanced techniques in the traditional sector, as well as the potential effects of land reform. Because the objective function is the weighted sum of income in the traditional sector and income in the rest of the economy, it was possible to use parametric programming to obtain solutions under the assumption of different policy weights on the two sectors. Table 11 presents the different objective functions and the corresponding weights assigned to each of the sectors. Objective function, OBJ2.5, assumes a strong policy emphasis on the traditional sector, while objective function, OBJ5.0, assumes a strong policy emphasis on the rest of the economy. Objective function, OBJ3.5, assumes neutral policy emphasis in that the weights are equal for both sectors. Table 12 shows the value of GDP, Y_T, and Y_R for each of the five time periods, for each of the

TABLE 11

Objective Function Weights Assigned to Y_T and Y_R by Time Period for Alternative Policy Emphases

Objective Function	$\frac{1}{(1+.04)^t}\delta_{Tt}$ [b] t =					$\frac{1}{(1+.04)^t}\delta_{RT}$ t =				
	1	2	3	4	5	1	2	3	4	5
OBJ2.5	.6866	.6347	.5868	.5425	.5020	.2942	.2720	.2515	.2325	.2158
OBJ3.0	.5885	.5440	.5030	.4650	.4305	.3923	.3627	.3353	.3100	.2875
OBJ3.5[b]	.4904	.4534	.4192	.3875	.3575	.4904	.4534	.4192	.3875	.3575
OBJ4.0	.3923	.3627	.3353	.3100	.2875	.5885	.5440	.5030	.4650	.4305
OBJ4.5	.2942	.2720	.2515	.2325	.2158	.6866	.6347	.5868	.5425	.5020
OBJ5.0	.1961	.1813	.1677	.1550	.1443	.7847	.7254	.6706	.6200	.5722

[a]The discount rate was assumed to be 0.04

[b]Corresponds to neutral policy emphasis

TABLE 12

Y_T, and Y_R by Time Period[a]

Selected Objective Functions

e

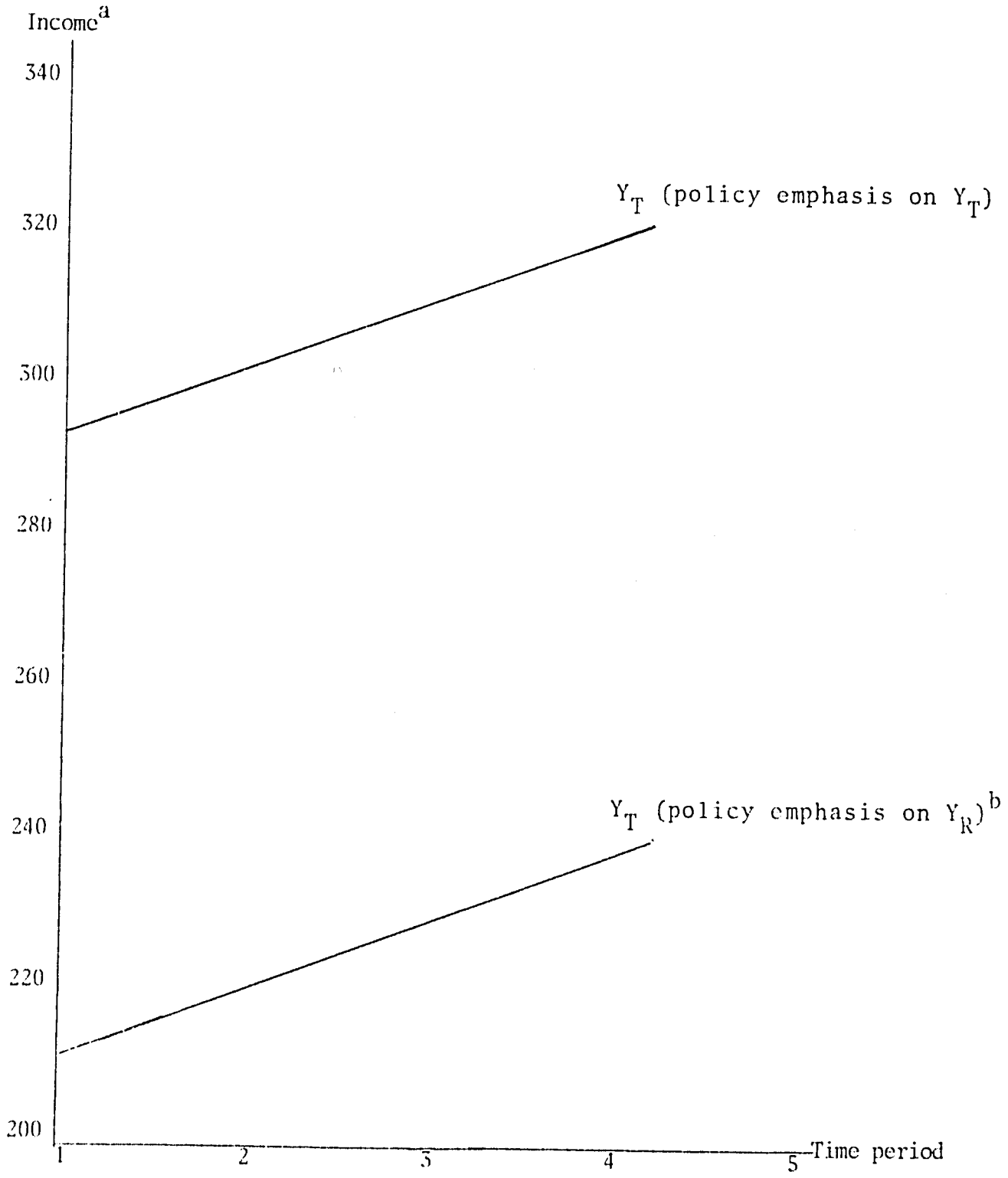
Y_{Tt} t = 1	2	3	4	5	Y_{Rt} t = 1	2	3	4	5
6.32	599.38	612.91	627.17	642.17	2824.02	3028.94	3246.84	3479.65	3728.13
3.02	436.08	449.62	463.88	478.88	2913.85	3118.77	3336.67	3569.48	3817.96
3.02	436.08	449.62	463.88	478.88	2913.85	3118.77	3336.67	3569.48	3817.96
3.02	436.08	449.62	463.88	478.88	2913.85	3118.77	3336.67	3569.48	3817.96

two years, so that the variables are expressed as two year totals

different objective functions. It should be noted that the solutions for the last three objective functions are identical. This is due to the fact that the feasible region is made up of planes which come together at corners, which would look like the face of a diamond. The existence of identical solutions, even though the policy weights are different, merely reflects the fact that the objective function is rocking on the same corner. When the weights are changed enough, then another solution becomes optimal. Objective functions with different policy weights were also used, but did not result in different solutions than those presented in the table. Table 12 also presents, what appears to be, a curious result which should be explained at this point. The solutions with heavy policy emphasis on the traditional sector show GDP higher than that for OBJ3.5, which corresponds to neutral policy emphasis. It might be tempting to interpret neutral policy emphasis as equivalent to maximizing GDP. The question arises as to why GDP would be lower when the objective was to maximize GDP. The anwer lies in the fact that the objective function also contains investment in the commercial agriculture and nonagriculture sectors (or the rest of the economy) for the last time period. Therefore, when the weights are changed with respect to Y_T, and Y_R, while the weights on I_A^5 and I_N^5 are the same, the objective function which is a plane, does not remain orthogonal to the Y_T-Y_R plane. The result is that it becomes optimal to invest more in the rest of the economy, in the last time period when policy emphasis is neutral than when the traditional sector is highly favored. Investment in the nontraditional sectors in the last time period is equal to 530.6 million dollars when the policy emphasis is on the traditional sector, while investment in the last period is equal to 608.04 million dollars when the policy emphasis is on the rest of the economy or neutral. The basic reason for this is the assumption that investment in the traditional sector is providing working capital and not long-term fixed capital.

As is characteristic of linear programming models, a "flip-flop" phenomenon is observed. When the policy emphasis is strongly in favor of the traditional sector, it is optimal to put all land in the traditional sector under the highest technology for every time period, so that there is no gradual technical change. On the other hand, when the policy emphasis is on the nontraditional sectors of the economy, the model assigns the lowest technology to all land in the traditional sector for all time periods, thus, the "flip-flop" nature of the solutions. However, these solutions are useful in indicating the possible range of improvement for the traditional sector. Figure 8 presents traditional income under different policy objectives by time period. The results show income in the traditional sector to be 38% higher in the first period and 34% higher in the last time period, when strong policy emphasis is placed on the traditional sector. Figure 9 and 10 show GDP under alternative policy objectives and modern sector income under alternative policy objectives, respectively.

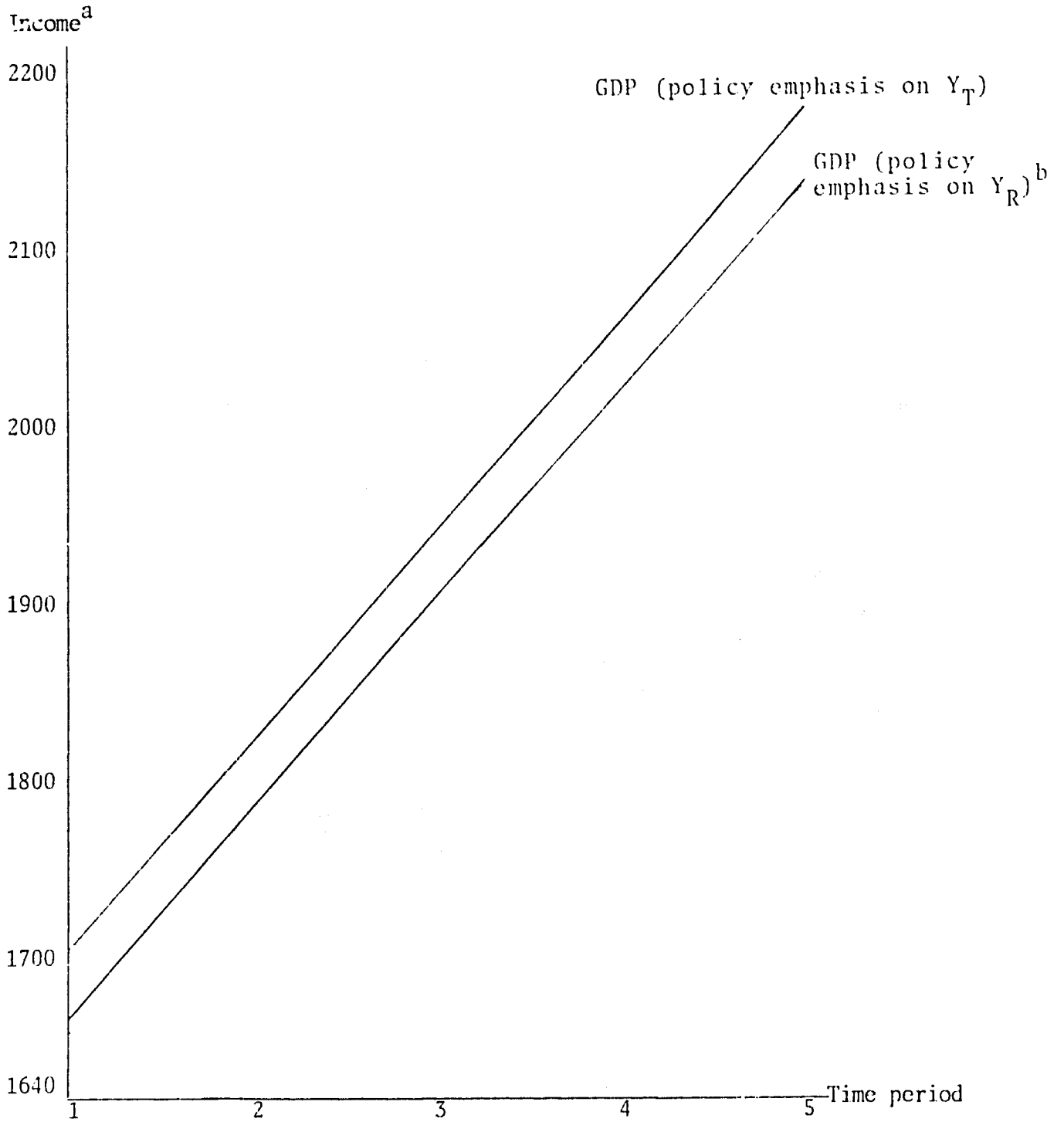
Figure 8. Traditional Sector Income
Under Alternative Objectives



[a]In $ per year

[b]Neutral policy emphasis also yields this solution

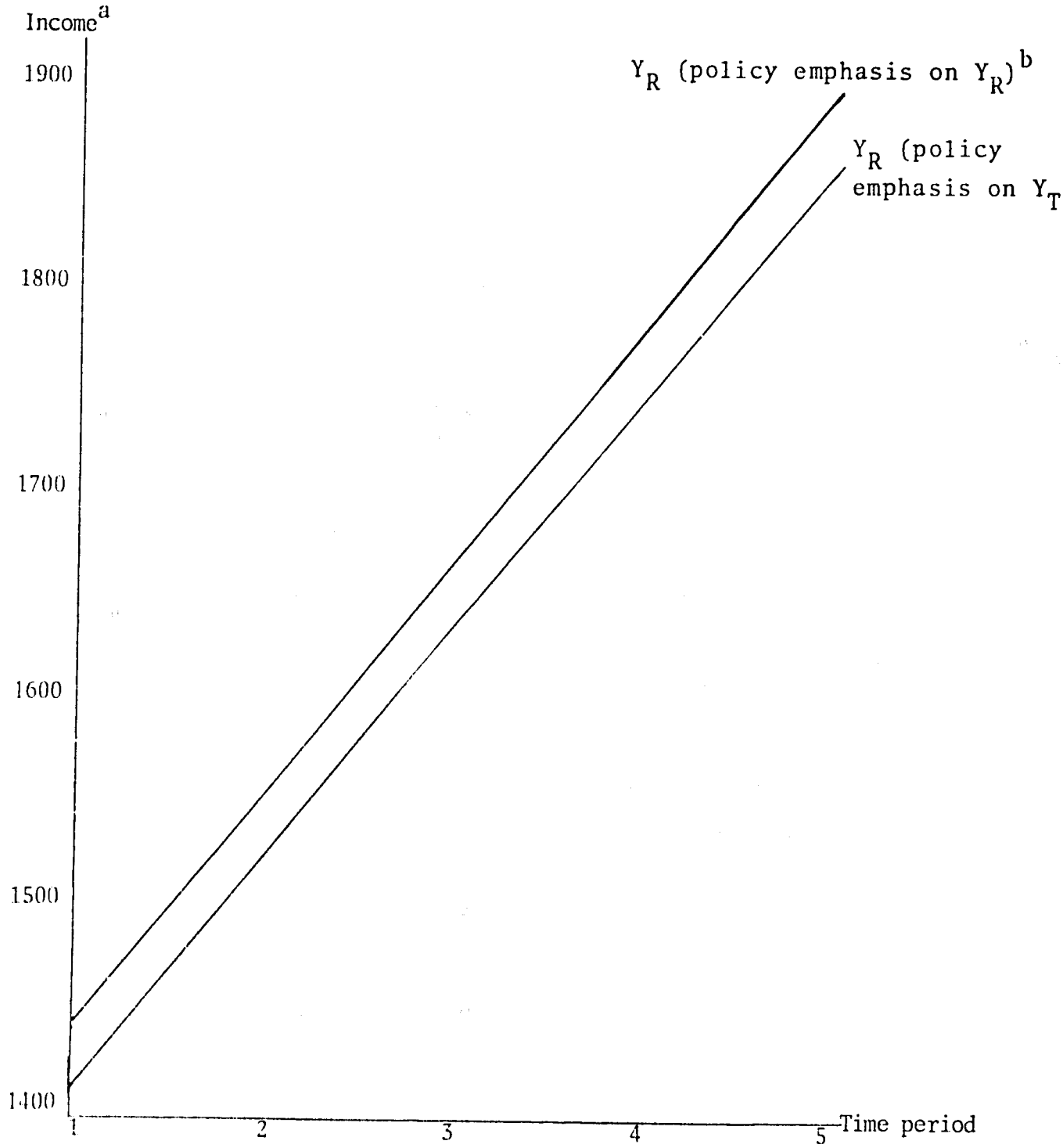
Figure 9. Gross Domestic Product
Under Alternative Objectives



[a]In $ per year

[b]Neutral policy emphasis also yields this solution

Figure 10. Modern Sector Income
Under Alternative Objectives



[a]In $ per year

[b]Neutral policy emphasis also yields this solution

Land Reform

The land reform experiment was carried out under the following assumptions. The assumed land area of the traditional sector for 1970 is 698 thousand hectares [Merrill, 1974]. Merrill calculates that 199,000 hectares of new land can be brought into production through colonization programs. According to Merrill, if an active agrarian reform program was implemented, which gradually shifted the land, now in farms larger than 45 hectares, to new farms smaller than 45 hectares, the distribution of land for the nine highland departments in year 2000 will be (including colonization):

Farm Size	% Farms	% Land
Less than 7 hectares	90.5	59.20
More than 7 hectares	9.5	40.80

Since this distribution is for the nine highland departments, it may overestimate the improvement for the entire country. Most large farms are outside the highlands area, so the distribution of land is more unequal outside the highlands. Also, opposition to land reform is likely to be greater in these areas. Therefore, we will assume a more conservative improvement given below.

Farm Size	% Land
Less than 7 hectares	50
Greater than 7 hectares	50

Total arable land for Guatemala will be 3752 thousand hectares presently in use, plus 199 thousand additional hectares brought into production through colonization. Therefore, total land area in the year 2000 will be 3951 thousand hectares. Assuming the above distribution of land after land reform, we obtain 1976 hectares available to the traditional sector. Subtracting the present 698 thousand hectares, we get an increase of 1278 hectares. This program is assumed to be complete in the year 2000. We will assume that an equal portion of the additional land is brought into production each year. Therefore, ΔZ_t = 85 thousand hectares for each two-year time period.

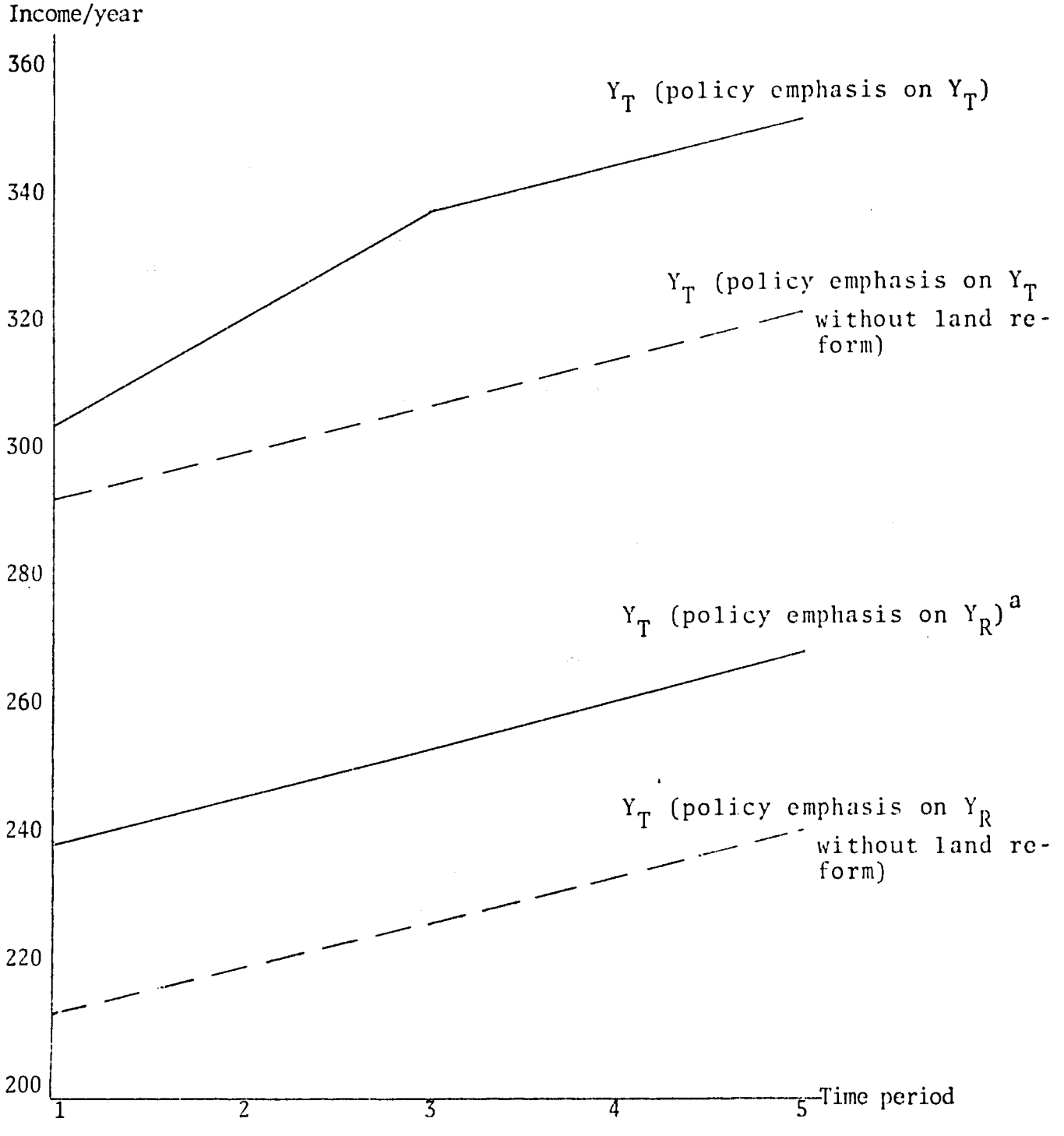
The results of the land reform experiment are presented in Table 13. The effect on traditional sector income is graphically illustrated in Figure 11. The land reform significantly improves income in the traditional sector. However, the solution under strong policy emphasis shows a significant decline in the growth rate of traditional sector income. This is explained by the fact, that over time, the proportion of land in the traditional sector, cultivated under the highest technology, declines. This indicates that there is a binding demand constraint upon traditional income. If the model was con-

TABLE 13. GDP, Y_T, and Y_R by Time Period and Selected Objective Functions Assuming Land Reform

Objective Function	Variable[a]														
	GDP_t					Y_{Tt}					Y_{Rt}				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
OBJ1.5	3419.78	3647.19	3888.07	4135.13	4398.62	607.31	641.34	675.85	690.11	705.11	2812.47	3005.86	3212.22	3445.02	3693.50
OBJ2.0	3419.78	3647.19	3878.63	4125.69	4389.18	607.31	641.34	654.87	669.13	684.13	2812.47	3005.86	3223.76	3456.57	3705.04
OBJ2.5	3419.78	3637.76	3869.19	4116.26	4379.74	607.31	620.37	633.90	648.16	663.17	2812.47	3017.34	3235.29	3468.10	3716.58
OBJ3.0	3361.44	3579.42	3810.85	4059.92	4321.40	477.63	490.69	504.22	518.48	533.49	2883.80	3088.73	3306.63	3539.44	3787.92
OBJ3.5	3361.44	3579.42	3810.85	4059.92	4321.40	477.63	490.69	504.22	518.48	533.49	2883.80	3088.73	3306.63	3539.44	3787.92

[a]Variables are expressed as two year totals

Figure 11. Traditional Sector Income Under Alternative Objectives Assuming Land Reform



[a]Neutral policy emphasis also yields this solution

strained to allocate all land in the traditional sector, excess capacity would develop in that sector. This is an important result, indicating that the impact of a rural development program combining the Basic Grains Program with land reform may be somewhat weakened due to limitations on domestic and export markets for the products produced by the traditional sector.

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