DIVERSIFICATION OPPORTUNITIES
AND EFFECTS OF ALTERNATIVE POLICIES
ON COSTA RICAN COFFEE FARMS

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INTRODUCTION

An Economic Background

Costa Rica is a small country in Central America with a population of 1.6 million people living on an area of 19,700 square miles (46, p. 11). The economy is dominated by agriculture which employed over 56 percent of the active work force in 1963 (45, p. 13). In addition, agricultural products accounted for approximately 30 percent of the gross national product in 1966 and about 80 percent of the value of Costa Rica's exports (17, p. 3). Allegor described Costa Rica as a nation of small farmers (3, p. 33). This characterization does not mean that land is evenly distributed among the population, since farms of over 100 manzanas represent only 10.5 percent of all farms and cover 70 percent of the total farmland area (23, p. 46). Nevertheless, the land distribution figures must be interpreted with a realization that many large farms are in remote areas and that, except for sugarcane and bananas, the intensively grown crops are dominated by small and middle-sized farms.

In recent years, Costa Rica enjoyed the highest per capita income in Central America. The estimated gross national product per person in 1965 was \$415 compared to an average of \$303 for all of Central America (55, p. 3).

In recent years Costa Rica has had a balance of payments problem. Foreign debts have had to be continually renegotiated. From 1950 to

1967 the value of exports of coffee, bananas, cacao, cotton, beef, and sugar increased from 592.1 to 702.8 million colones (56, p. 34). While the value of exports has increased despite unfavorable price trends, the value of imports has increased at a much faster rate. The value of exports exceeded the value of imports by 24.8 percent in 1967 and by 12.2 percent in 1968 (24).

Production of the basic food crops has exhibited erratic growth since 1950. Corn imports exceeded exports in 1951, 1954, 1956, 1959, 1964 and 1966. Per capita consumption of corn in 1966 was below the 1950 level (56, p. 42). Rice production has almost tripled since 1950, with a stronger upward trend occurring after 1958. While the change is largely due to an increased acreage, the average yields have increased since 1955 (56, p. 5). Per capita consumption of rice has increased. Bean production has also increased significantly, doubling the 1950 output in 1967. However, net imports of beans occurred in 1951, 1956, 1957, 1959, 1961, 1962 and 1964. Per capita consumption has increased 25 percent since 1950 (56, p. 28).

The Costa Rican population increased from 1,028,175 in 1955 to 1,648,815 in 1960 (15, p. 2), an annual average increase of more than 4 percent. While population growth increases the demand for food, this demand is also increased by a rise in per capita incomes. If food output is to keep pace with the demands of both population and income growth, further changes in inputs and technology will be required (13). The allocation of scarce foreign exchange to food imports limits the ability of a developing nation to purchase capital goods needed for economic growth (48, p. 5).

Another problem facing Costa Rican planners is public finances.

The costs of governmental services are increasing. Education is an example (55, p. 33). Schools are being expanded but more and more children crowd them. With over 35 percent of the population under ten years old, education is costly (19, p. 47). Rapid population growth slows occupational changes (1).

Thus while the Costa Rican economy has given the nation the highest per capita income in Central America and supports the most advanced social and educational programs in the region, it faces demanding requirements if it is to continue to grow.

The Importance of Coffee to Costa Rica

Coffee is Costa Rica's leading agricultural commodity, the chief export crop, and a major user of agricultural credit and labor. Coffee has historically accounted for 17 to 26 percent of the value of agricultural output (54, p. 37). Despite a long history of production, coffee output has increased markedly in recent years. From 1955 to 1963 coffee output was doubled. Yields increased 27 percent while acreage increased over 58 percent (53, p. 10). Considerable effort was put into research and extension work which emphasized the use of modern inputs in coffee production. Higher coffee prices in the 1950's encouraged the expansion of coffee onto new lands. The modernization of coffee production is indicated by the fact that in 1963, 27 percent of the farms reported fertilizer use on 53 percent of the land planted to coffee (23, p. 176). Fertilizer responses gave 18 to 233 percent increases in coffee yields in trials running from 1952 to 1957 (69, p. 60). Since 1963, production increases indicate an even larger use of off-farm inputs. In 1967, coffee output

was more than three times the average output in the 1948 to 1952 period (29, p. 63). Thus coffee production has led in a change from traditional toward modern farming methods.

Coffee is the major source of foreign exchange for Costa Rica. It accounted for 38.9 percent of total value of exports in 1966, 41.2 percent in 1965 and 42.2 percent in 1964 (15, p. 13). Thirty percent of the economically active population is associated with the coffee industry (54, p. 37). This underestimates coffee's importance as a source of wage earnings since many children harvest coffee and are not considered part of the economically active population. The harvest season usually coincides with school vacations. Also, earnings from coffee picking greatly exceed other farm labor earnings.

Another benefit that comes from coffee production is soil conservation. A well-cared-for coffee planting protects the soil from driving rain and contour ridges that slow runoff are permanent and reinforced with woody root systems. Much of the land utilized by coffee is unsuitable for annual cropping unless very elaborate terracing is used (67).

Lastly, coffee is a source of tax revenue. Taxes of \$0.45 per quintal of exported coffee, ₡2.00 per quintal of coffee consumed internally, and ₡0.20 per fanega of coffee fruit processed at the beneficios support the operations of the Oficina del Café. In addition, an advalorem tax contributes to the national treasury. This advalorem tax is graduated in the following manner: 10 percent if the average price exceeds \$42.50 per quintal, $7\frac{1}{2}$ percent if the average price falls between \$40.00 and \$42.50 per quintal, 5 percent if the average price falls between \$37.50 and \$40.00 per quintal, and $2\frac{1}{2}$ percent if the average price falls between \$35.00 and \$37.50 per

quintal. No advalorum tax is paid if the price falls below \$35.00 per quintal (54, p. 56).

Declines in coffee prices are burdensome to governments which depend upon coffee earnings for foreign exchange and tax revenue (30, p. 15). This is particularly true in Costa Rica where a 14 percent decline in price resulted in a 57 percent loss in tax revenue per quintal and a 3 percent decline in price resulted in a 53 percent loss in tax revenue per quintal in the marketing years from 1965-66 to 1966-67 to 1967-68. The price decline from 1966 to 1968 brought about a drop in tax revenue estimated at 24 million colones (55, p. 10).

The Marketing Situation for Coffee

Historically, coffee production has gone through highly cyclical price periods. Prices fluctuated in a cyclical pattern accentuated by periodic unplanned changes in supply caused by unfavorable weather conditions in Brazil (32, p. 454). When drought and frost cut Brazil's output the price would rise. This high price encouraged renovation of old coffee orchards and the planting of new ones. Later, when recovery of damaged groves occurred, output surpassed the earlier level. Prices then were pushed to new lows causing abandonment or neglect of coffee farms until unfavorable weather again stimulated high prices. Over the years, there have been short periods of shortage and high prices followed by long periods of surplus and low prices (59, p. 8). These drastic price fluctuations stimulated coffee producers to seek remedial schemes. The first of these was a Brazilian law blocking new plantings in 1902. Politically

unpopular, this law was repealed and followed by valorization schemes with which large quantities of coffee were purchased and held off the market (32, p. 456). Brazil borrowed from British banks to make coffee purchases in 1906, 1917, 1921 and 1927. Larger and larger crops were encouraged which became more and more difficult to store. Brazil burned over 78 million bags of surplus coffee from 1931 to 1944 (73, p. 423).

Coffee production in other Latin American countries expanded in response to Brazil's price supporting activities. Growth elsewhere caused Brazil to market a smaller percentage of the world coffee (73, p. 425).

International agreement to control coffee output was first attempted in Bogota in 1936. Later, the Inter-American Coffee Agreement was signed by 14 producing countries and the United States. Selling quotas were established and the agreement lasted from 1941 to 1948 (73, p. 423). In 1957, coffee producing nations agreed upon a voluntary system of export regulation. This agreement failed to check the downward price movement (59, p. 13). Finally, the International Coffee Agreement received the support of 46 producing and consuming countries in 1963. By chance, a severe frost cut the Brazilian output that year and, as a result, quotas were increased to give help to the coffee consumers as prices rose (59, p. 14). The demand for coffee is believed to be inelastic with respect to price. If this is true, a free-market solution would result in lower gross income to producers than would occur if output were limited by some kind of a cartel arrangement. Economists generally view trade agreements with a skeptical eye. Both experience and theory show that, with

price maintenance at or above a free-trade level, pressures and temptations arise to break or by-pass the agreement since high prices tend to encourage more production (37, p. 108).

Nevertheless, the International Coffee Agreement has reduced price fluctuations and is considered to be effective enough to justify extension for five more years from 1968 (8, p. 188). However, the reduction in world output from 1965-66 to 1966-67 occurred mostly in Brazil where weather has historically caused wide production variation. The 1963 Agreement was concerned with regulating sales and made no attempt to regulate production.

In 1968, a new article was written into the International Coffee Agreement setting up the Diversification Fund (34). This change provides for compulsory payments (U. S. \$0.60 per bag in excess of 100,000 bags) into the Fund. This acts as a tax on coffee. Extra incentive is given to coffee producing nations to devise crop diversification projects. Eighty percent of the compulsory payments can be used within the producing country on approved projects. If not used domestically, the unused payment must be paid to the Fund in freely convertible currency. Thus each country will be motivated to develop local diversification projects by the desire to conserve scarce foreign exchange.

Producing countries have used different programs to check coffee output. As mentioned earlier, Brazil first attempted to control output in 1902 with a law prohibiting new plantings. More recently payments have been made for coffee removal (60). Participation in the program has been voluntary, with 648 million coffee trees pulled out from June, 1962 to December, 1965. Plans had called for the removal

of two billion trees and part of the lack of response was blamed on inflation which lowered the value of the fixed payments from \$0.04 to \$0.01 per tree. The effect on coffee output was small. The program included no restriction on planting. In Colombia, International Development Bank (IDB) loans have been used to further credit, infrastructure, education, commercialization and industrialization of alternative products. In Mexico, rubber, citrus and avocado plantings are being promoted in a program directed at the small coffee producer (27). In El Salvador, sugar, corn and rice production has been expanded. Modern corn and rice production gave returns reported to range between \$3.00 and \$7.50 per \$1.00 spent on new inputs. Nevertheless, the expansion of cereals was accompanied by a reduction in cotton and beans, rather than coffee (74). In Guatemala, pilot tests of tea, citrus, dairy and oil palm have been initiated. Over \$1.9 million in foreign money has been invested in the program. Total costs surpassed \$5.8 million invested on 282 farms covering 3,900 hectares (6). Guatemala also is developing a rubber industry. In 1965, rubber was planted on 26,000 acres. Projections estimate gross returns of \$24 million from 80,000 acres (75).

In Costa Rica, credit for new coffee plantings has been restricted. In addition, the Universidad de Costa Rica, the U. S. AID Mission, the University of Florida, and the Centro para la Promoción de Exportaciones and Inversiones cooperated in a series of observation trials in six locations scattered throughout the western part of the coffee growing region. The municipality of Turrialba has initiated a regional diversification program with the Instituto Interamericano de Ciencias Agrícolas. Financial support from the Oficina del Café and

the Agency for International Development (AID), plus technical assistance from the Instituto Interamericano de Ciencias Agrícolas, the Peace Corps, and the Ministerio de Agricultura, makes this a truly cooperative venture. The emphasis is primarily on research with a rapid follow-up of pilot commercial plantings. The project began with basic studies of fast growing trees, Tilapia fish ponds, and macadamia nut production. The stated main purpose of the project was to institutionalize an attitude of dynamic change (9). While it is still too early to evaluate results, leaders in another municipality have talked of imitating Turrialba with a diversification project of their own.

In summary, a review of the literature on Latin American coffee diversification showed more discussion and hypothesizing than practical results.

The Pros and Cons of Diversification

There has been much discussion of diversification in recent years as a method to foster economic development. In a comprehensive study, Dalrymple (22) has compared monoculture and diversification. The advantages of monoculture include the following:

1. In some cases the monoculture crop has a clear comparative advantage both at domestic and international levels. The financial gap between the monoculture crop and next best alternative has been found to be too wide to permit rational change.
2. It may be easier to raise yields to give higher returns from an established crop than to press for more complex cropping systems. The short-run returns to increased specialization with economies of

scale may be quite high. The new knowledge and skills required to improve production of an existing crop may be easier to learn than the technical requirements of a totally new crop.

3. Monoculture is generally focused on export crops which provide a developing country with needed foreign exchange and an easily administered tax system.

4. Certain crops have more prestige and social status than others.

The disadvantages of monoculture bring out accompanying economic difficulties:

1. Producers under monoculture are subject to high risk induced by technical change and insect and disease problems. This is often labeled "putting a lot of eggs in one basket."

2. Because many of the monoculture crops are perennials, a production lag may follow a decision to increase output. By the time the crop comes into production considerable investment has already been made. Excessive reaction to favorable price situations may occur when this lag follows a major change in resource allocation. Readjustment of supply to face a lowered price will be sluggish even in the face of losses since marginal costs may be easily covered.

3. The low price elasticity of demand for coffee results in sharp, short-term price fluctuations caused by weather and biological factors. The resulting high prices in the short run may trigger irreversible investments. These investments plus technological advances can be expected to increase supply while demand is not likely to increase faster than population growth. As a result, prices are expected to weaken over time.

4. Trade agreements limit sales to key markets and therefore increase both price and gross returns for the commodity with an inelastic demand. Unless each producing country takes actions to correct the internal distortions of high incentives for the commodity covered by trade agreements, an imbalance encouraging overproduction of that commodity will result (53, p. 9).

The advantages and disadvantages of diversification are roughly the inverse of those of monoculture. Diversification may be advantageous if it more fully utilizes labor and reduces economic risk (48, p. 24). A number of different sources of income gives protection against severe loss caused by insects, disease or bad weather conditions which may affect one particular crop but not others. Labor requirements may be spaced in such a way that one crop uses labor when another has a slack work period. Shifting from an export crop to food crops can lead to improved nutritional levels, especially if more fruits and vegetables are introduced into the diet. Also, import substitution may save scarce foreign exchange (22, p. 27).

On the other hand diversification faces certain limitations. Research has been focused on a few major export crops (22, p. 39). Without much experience or local scientific investigation to support a new enterprise, the innovating producer faces higher uncertainties with respect to the crop response to unfavorable factors and conditions (41, p. 1). The market for the alternative crop may not be sufficient to absorb expanding production at profitable prices (22, p. 41). Even if a potential demand exists, the marketing facilities may not be adequate to move the new output to consumers. The economies of scale may result in poor efficiency as a greater number of crops are produced and volume of some crops is reduced. This is

particularly a hazard for a new crop introduced without sufficient volume to utilize efficient processing machinery.

In cases where the established crop is a perennial, a high percentage of the costs are fixed. Therefore, replacement by an alternative requires that total costs, since all costs are variable, be considered in comparison with the variable costs in the case of the established crop. Also, costs associated with removing the old crop must be added into the cost of establishing the new enterprise.

Another problem arises if a new crop uses either more or less labor than the established crop (22, p. 38). If the labor requirement is much higher, labor scarcity may prevent adequate handling of the new crop. If much less labor is used, unemployment has social ramifications that may be prejudicial to the establishment of a new industry.

The quantity of research, extension work and information services will have to be expanded if changes require more complex agricultural systems (48, p. 24). Diversification projects are likely to fail on farms where administration and management inadequacies greatly limit the returns to coffee because the new enterprises are likely to be even more difficult to manage (27).

Approaches and Attitudes toward Diversification

Crop diversification is defined as a movement away from monoculture with the growing of new or additional crops (22, p. i). More detailed descriptions may be conflicting and the evaluation of diversification as a policy measure depends greatly upon just what meaning is used. A most restrictive definition, and one often thought of, is the transfer of land from monoculture to alternative uses. However,

other resources besides land may be shifted from one use to another. Thus, diversification occurs if operating capital or labor is put to alternative use. For instance if labor or fertilizer is applied to strawberries rather than to coffee, diversification occurs. Diversification may even occur without a shift in resources or a reduction in primary crop output. This is possible if unused resources are associated with monocultural production. Therefore, if a farm were to begin to grow a crop of dasheen on swampy ground formerly unused, using surplus family labor and operating capital, this would be an example of diversification. Thus for the purposes of this study, diversification is defined as a positive action which reduces the relative importance of the primary crop.

Crop diversification may occur at either the farm level or the national level. A recent advisory group proposed that Costa Rica should concentrate diversification efforts on areas unsuited for coffee, where mechanization was feasible (68, p. 3). The program in this case would be to expand output using resources not now used to grow coffee.

Crop diversification may either expand domestically consumed crops or promote new export crops. Although import substitution is recognized as beneficial, planners seek to increase earnings of foreign exchange with new exports. The export demand for a product facing a small country is often highly price elastic (57, p. 1). Thus, generally the new export crop has an advantage over domestic crops in that price will remain more stable as output is expanded. The small size of the domestic market is coupled with a shortage of capital funds and modern know-how to limit diversified economic potential (16, p. 33).

Furthermore, overproduction of basic food crops may result in government losses if high support prices are coupled with export subsidies (61).

Others suggest that domestic crops offer better diversification possibilities because benefits of technological change are passed on to the consuming countries (66, p. 432). Since a particular good from one country has perfect or close substitutes produced in other countries, the demand curve facing each country is elastic. However, the common agricultural export crops are inelastic when the entire world market is considered since they do not have close substitutes, do not have many uses, and do not take a large share of the consumer's income (44, p. 41). After a technological change is widely adopted, the result of increased output is often lower gross revenue. In this situation, the consumer benefits from lower prices and a higher real income.

The innovator may initially supply the domestic market when low early yields are compensated by high prices. Later, costs may be reduced to permit export or industrial use at much lower prices. In addition, the scale of operations needed for new export ventures exceeds the capacity of existing producing units and marketing facilities (17, p. 12). The development of a new export crop requires efficiency if it is to meet the established competition.

Another area of debate centers around the question of who should diversify. Two nearly opposite views have developed: an efficiency criterion of marginality proposes to remove the low profit producers. In opposition, a criterion of welfare seeks the removal of those least hurt by shifting to alternative production.

The removal of marginal producers is deemed desirable by both the Oficina del Café in Costa Rica and the Asociación Nacional del Café in Guatemala (54, p. 32; 27). Fernández (27) defined marginal farms as those where costs exceed returns and also small farms where returns are low. One may note that this approach avoids antagonizing the politically influential in Guatemala as marginal farms are "liberated" for other uses. In Costa Rica, selective credit restrictions were used to limit the expansion of coffee, particularly into areas producing low quality-low yield crops. The Oficina del Café favors this policy because it helps to maintain a higher average of quality as well as to restrain production.

Newman (53, p. 14) has criticized the marginal producer definition for being concerned with absolute rather than comparative advantages. Small farms are unsuited for such alternatives as dairying and fruit production because they cannot take advantage of economies of scale open to large operators. Small farms also lack reserve capital or credit availability to enable them to invest in the more productive alternatives. They are less able to withstand possible loss of a new venture. The opportunity cost associated with removing coffee includes interest charges on foregone income, which may be limiting for farms near the subsistence level of income when perennial alternatives are considered.

Welfare considerations cannot be quantified for interpersonal comparisons. However, value judgments need not be made if the level of alternative output is used to evaluate different policies of diversification. The problem then becomes the calculation of the net costs of removal of a quantity of coffee from production on different farms.

If the means of production control is alternative use of land, this may be stated algebraically as follows:

$$C_r = P_c - C_c - V_a + C_a + C_s$$

where

C_r = net cost of removing one fanega of coffee,

P_c = price of coffee,

C_c = cost of producing one fanega of coffee

V_a = value of alternative product produced with resources made available as coffee is reduced by one fanega,

C_a = cost associated with producing V_a ,

and

C_s = cost of removing trees producing one fanega of coffee.

Thus, the comparative advantage in coffee production may differ from the absolute advantage where $C_r = P_c - C_c$. If coffee is purchased and destroyed, the cost is higher as $C_r = P_c$.

A more general formula can be stated for calculating the unit cost of coffee removal.

$$C_r = \frac{I_1 - I_2}{Q_1 - Q_2}$$

where

C_r = net cost of coffee removal

I_1 = net income before change

I_2 = net income after change

Q_1 = coffee production before change

Q_2 = coffee production after change

Ideally, diversification would seek to reduce coffee without reducing income. However, given a price situation which stimulates

excess use of resources in coffee production, a more practical policy would attempt to minimize the costs of controlling output.

The Problem and Objectives

Although coffee is Costa Rica's most important commodity, continued dependence on that one crop is considered detrimental to prospects for economic growth. This harsh statement is supported by a political-economic situation in which the sales of coffee to the high consumption markets is now limited by international agreement. Thus if substantial growth is to be achieved, it must occur in some other segment of the national economy.

Technological changes are occurring in coffee production. These changes enable coffee to be produced at lower unit costs as modern inputs are added to traditional land and labor. The result is to increase yields. If resources are not shifted away from coffee, this increases production. The problem then arises as to which resources should be shifted to what alternative uses. Also, what policy measures will facilitate changes which are both efficacious and equitable?

One may also ask, are Costa Rica's farmers functioning as profit maximizers? Theodore Schultz has claimed that in traditional agriculture farmers are not only profit maximizers but that they also are quite efficient profit maximizers (62, p. 44). However, most of the farms studied do not truly fit the definition of traditional agriculture used by Schultz (63, p. 30). Cultural techniques for coffee have not remained unchanged for generations and further changes are occurring (32, p. 432). Costa Rica's emphasis on primary education already has accomplished much toward the investment in human resources

necessary to change traditional attitudes (63, p. 201). Schultz has designated the human agent as the key variable in explaining differences in agricultural productivity (63, p. 17). The existence of experimental farms, scattered research plots, extension agents and agricultural schools also takes Costa Rica out of the category of traditional agriculture.

Costa Rica admittedly does have many traditional farmers. However, the threat of overproduction of coffee does not come from that direction. Recent yield increases indicate non-traditional behavior, while increased coffee acreage has been relatively unimportant (15, p. 21).

Schultz describes a transitional classification of agriculture between the traditional and the modern (63, p. 107). Vast disequilibrium is said to exist with differences in marginal productivity and overuse or underuse of factors. The expanding use of fertilizers and pest control chemicals (15, p. 7) indicates that transitional changes toward modernization are occurring in Costa Rica.

Nevertheless evaluating the farm case studies with respect to expectations given by Schultz's theories may be interesting. Traditional farm situations could be expected to give marginal value products near or at current prices of resources. On the other hand, transitional farm situations may put extremely high values on certain resources. Linear programming solutions may be compared with actual farm operations to judge the efficiency of farm decision makers. This may be of particular interest in explaining the continuance of traditional methods with some crops while changes occur with others.

Specifically the objectives of this study were to evaluate farm

income opportunities from producing coffee and from alternatives and to determine the effects that selected programs would have on coffee production, resource use and incomes. At the same time, comparisons can be made of current resource use and optimal resource use to test the hypothesis that the farmers are income maximizers and that traditional economic behavior has economic motivations. In addition, the comparisons may be used to determine what changes or adjustments in farm operations would be profitable.

SCOPE AND METHOD OF STUDY

Selection of Areas and Farms

Coffee is grown in Costa Rica under a wide range of climatic and ecological conditions. Three geographic areas were included in this analysis. The data were taken from a study carried out under a University of Florida - AID Contract in Costa Rica, No. 1a-261. Budgeted comparisons between coffee enterprises and leading alternatives in 12 areas are given in An Economic Analysis of Coffee Producing Areas, Costa Rica (11).

Palmares-San Ramón, Alajuela and Acosta were the areas selected for this intensive study. This selection was based on the following criteria:

1. Coffee and alternative crops should be found growing under similar ecological conditions.
2. Enough coffee should be produced to make changes important to national totals.
3. Different areas should represent a wide range of coffee productivity and alternative choices.

Some consideration was given to including the Turrialba area in this study. However, the diversification project in that area was just beginning to generate completely new data when this work was undertaken.

Within the three areas selected, the local extension agents

selected farms they regarded as typical of size and class categories common in each particular region. Data were collected by the agents listing the resources available and the resources used on each farm. A monthly breakdown of labor was supplied for each enterprise. In addition, budgets for several crops grown in the areas were made available from the Banco Nacional de Costa Rica and the Banco de Crédito Agrícola de Cartago. The list of enterprises was further supplemented by crop cost study reports of the Ministerio de Agricultura.

It is admitted that the farm case study approach cannot be statistically supported. However, by drawing upon the prior knowledge of the local agricultural scientists, costs could be held to a fraction of the costs of working with a large random sample. Because it is likely to be the better farmers who contact and work with the extension agents, one may expect that the "typical farms" of the extension agents may be above average. Nevertheless, this direction of bias need not be undesirable since it is this group of farmers who are most likely to first respond to economic incentives with either increased coffee output or diversification to alternative products.

Furthermore, the farms selected are in no way expected to be averaged to give a quantitative measure of policy response for more than each farm itself. The generalizations possible must be limited to direction and nature of change which may in turn lead to speculations concerning the response of the total coffee industry.

Although quantitative analysis is made at the farm level, extrapolation to larger areas must be with descriptive or qualitative anal-

ysis. In this manner, associations can be made between policy responses and various resource situations or enterprise possibilities. The uniformity, irregularity or lack of response can be noted for various policy alternatives. Thus the sample may indicate the kind of farm likely to support or oppose a particular political measure.

Description of Farms Studied

The farms selected for analysis are all located on the Pacific side of the Continental Divide. Farms were selected to represent the most common size-type categories found in the three areas.

Palmares-San Ramón

This area is made up of the intensive coffee-growing districts of the cantons of the same names. The Canton of Palmares, except for the districts of Candelaria and Esquipulas, which are not well suited for coffee, reported coffee on 94 percent of the farms and 37 percent of the land in 1963 (25).

The soils are fluvio-lacustrine groups containing diatomite (10, p. 3). Internal drainage may be a problem on level areas. A distinct dry season extends from December into April and Good Hard Bean (2) type of coffee is grown at elevations between 900 and 1,200 meters. Practically no rain falls from December to February (64). In the districts of San Isidro and San Ramón of the canton of San Ramón the Good Hard Bean type of coffee is produced at elevations of 1,000 to 1,200 meters. In these districts, coffee utilizes 12 percent of the land and is found on 83 percent of the farms. Tobacco, corn and beans are the major crops after coffee in the combined area. According to the 1963 census, coffee was grown on 2,783 manzanas,

corn on 417 manzanas, tobacco on 314 manzanas, beans on 226 manzanas, and sugarcane on 106 manzanas. Coffee output of the districts within the area made up over 3.6 percent of the national total and yields were roughly 37 percent above the national average in 1963 (25).

Eight farms were used to cover a range of small, medium, and large units growing coffee alone and in combinations of coffee and tobacco.

Farm 1 is a small coffee-tobacco unit in San Ramón. It is situated at an elevation of 1,080 meters on land described as moderately rough. The farm owner applied modern technology in the forms of fertilizer, insecticide, herbicides, and foliage fertilizer. The farm contains five manzanas with three manzanas planted to coffee and two manzanas planted to tobacco and corn. The labor force was made up of two hired male employees plus the family labor of a man, a boy, and two girls. Fixed expenses, including permanent labor, taxes, depreciation and maintenance, and interest on the land investment totaled ₡6,186. Short-term operating capital including credit was estimated at ₡4,400.

Net farm income was calculated as gross returns less reported annual expenses and estimated fixed costs including rent, taxes and hired permanent labor. Net farm income was estimated at ₡22,500. The farm was chosen as an example of mixed cropping using modern technology and hand labor.

Farm 2 in San Ramón is a small farm specializing in coffee. Coffee was grown on all its seven manzanas. Labor was supplied by five male and two female employees plus the family labor of two men and two boys. The fixed expenses, including permanent labor, totaled ₡16,690. Operating capital and credit available for variable costs

totaled ₡4,000. Net farm income was estimated at ₡15,250. This farm was chosen as an example of a specialized modern coffee producer.

Farm 3 in San Ramón is a larger farm producing coffee, corn and tobacco. The farm covers fifty-six manzanas of which fifty manzanas were planted to coffee. The farm has a flue-cured tobacco contract for three manzanas. There were nine permanent employees and an administrator. The fixed expenses totaled ₡60,100 and combined operating capital and credit totaled ₡71,100. Net farm income was estimated at ₡34,130. This farm was chosen as an example of a larger farm in the process of undergoing technological change.

Farm 4 is located in Palmares on nearly level land at an elevation of 980 meters. It is a middle-sized farm growing both coffee and tobacco. The farm reported fifteen manzanas planted to coffee and five manzanas in flue-cured tobacco. The farm hired two permanent employees and family labor consisted of three men, three girls, and two boys (part-time). Fixed expenses were calculated at ₡14,840. Annual operating expenses were ₡16,900. The net farm income was estimated at ₡14,700. This unit was selected as an example of a farm specializing in tobacco with low yielding coffee grown on other land.

Farm 5 is a medium-sized coffee farm in Palmares. The land is nearly level at an elevation of 1,020 meters. All ten manzanas were planted to coffee. The farm work was done by four men; two were hired and two were members of the owning family. The fixed costs were estimated at ₡10,732 and the sum of the operating capital and short-term credit amounted to ₡6,400. The net farm income was estimated at ₡15,520. This farm was representative of a level of technology commonly used on farms slowly adopting changes.

Farm 6, also located in Palmares, is found on gently sloping land at 1,030 meters' elevation. It is a small farm with four manzanas of land of which 3.75 manzanas were planted to coffee. The farm hired four permanent employees. It had no administrator nor family workers. The ₡12,480 estimate of fixed expenses included very high permanent labor costs. There were ₡4,000 available for annual expenses, including credit and operating capital. The farm operated at a loss estimated at ₡6,760. This farm was chosen as an example of a small property owned by an absentee owner.

Farm 7 is located on moderately rugged land at 1,025 meters' elevation in Palmares. It is a small farm of six manzanas with three manzanas of coffee and one manzana of sun-cured tobacco reported. Pasture was grown on two manzanas. The farm employed one man and extra work was supplied by two members of the owning family in times of emergency. Fixed expenses were calculated at ₡6,000 and ₡4,300 were reportedly available for variable expenditures. The estimated net returns were ₡3,345. This unit was selected to represent a small farm with mixed production.

Farm 8 is also located on moderately rugged land in Palmares. It covers two manzanas of land of which one manzana was planted to coffee and one-half manzana is planted to sun-cured tobacco. One permanent employee was hired and two men and two boys (part-time) of the owning family worked on the farm. Fixed expenses were estimated at ₡2,882. Operating capital and short-term credit was limited to ₡900. The coffee planted was not yet in production but anticipated yields gave expected annual returns of ₡2,653. This farm was selected as an example of a very small farm using multiple cropping.

Alajuela

The Alajuela area is located around the town of the same name. The land is made up of rolling hills with occasional areas of nearly level topography. In general, the soil is rich, being influenced by reoccurring ash fall, which results in andosols with high organic matter content, although considerable variation is found in both topsoils and subsoils (71, p. 26). The elevation ranges between 700 and 1,100 meters. The districts of Alajuela, San José and Desamparados were used to represent the region in the 1963 census data.¹ In 1963, average coffee yields for these three Alajuela districts were 27 percent above the national average and coffee occupied 1,980 manzanas. In the same year, there were 82 manzanas of pineapples, 137 manzanas of corn, 186 manzanas of beans, 17 manzanas of tomatoes, and 14 manzanas of cassava reported (25). Coffee was reported on 76 percent of the farms and occupied 26 percent of the land area in 1963.

Although rains may occur throughout the year, a dry season extends from December into April (64). The coffee produced is the Hard Bean type (2). The representative districts selected from the 1963 census produced 2.43 percent of the national output of coffee. However, the ecological conditions of these districts extend into parts of adjacent districts.

Four farms were selected for study from this region. Farm 9 is located near an elevation of 1,100 meters on gently rolling land in Alajuela. It is a large family farm with 40 manzanas, all in coffee.

¹Political subdivisions do not coincide well with ecological areas; therefore, the census data must be interpreted cautiously.

Labor was supplied with ten permanent employees and the family labor of two men and two boys (part-time). The fixed expenses were estimated at ₡48,575 and short-run credit and operating capital totaled ₡22,200. The estimated net returns were ₡90,000. This unit was chosen to represent large coffee farms with both good coffee and horticultural possibilities.

Farm 10 is located on rolling land above 1,000 meters. All of its 15 manzanas were planted to coffee. Labor was supplied by five permanent employees and two men and a boy of the family. The fixed expenses were estimated at ₡21,875. The operating capital and annual credit totaled ₡15,750. Estimated net returns were ₡17,160 but young plants raised expected future returns to ₡30,000. This farm was selected to represent the medium-sized specialized farm with good alternatives.

Farm 11 covers 10.5 manzanas of nearly level land at 700 meters elevation in Alajuela. Coffee was planted on five manzanas. Pineapple was grown on the remaining land. The farm utilized the labor of one hired employee and one man, two boys, one woman, and one girl of the family labor force. The fixed expenses were estimated at ₡9,670. A sum of ₡8,850 was available for annual operating expenses. Farm income was estimated at ₡42,980. The horticultural crop was sold into the high-priced fresh fruit market. If the farmer received processing prices for the pineapple, farm income would fall to ₡9,330. Pineapples would be discontinued since returns at processing prices would fall to about one-half of the cost of production. This farm was chosen to represent the middle-sized producer of coffee and fresh market fruit.

Farm 12 lies on rolling land at 1,100 meters near Alajuela. The farm contains 5.5 manzanas of land of which 2.5 manzanas are planted to coffee and the remainder is planted to sugarcane. Five men made up the farm's work force; two were hired and three were members of the owning family. The fixed expenses were estimated at ₡7,905 and credit and capital for annual expenses summed to ₡1,115. The annual net return to the reported sugar and coffee enterprises was estimated to be ₡6,122. This farm was chosen to represent small mixed-crop farms.

Acosta

This area is around San Ignacio de Acosta. This zone lies to the south of the Central Valley on rugged, eroded latosols of an intermountain valley. The coffee of San Ignacio is mostly grown at elevations between 900 and 1,200 meters. In the 1963 census, 98 percent of the farms reported growing coffee on 15 percent of the area. In 1963, coffee was reported on 1,098 manzanas which greatly surpassed 317 manzanas of beans, 174 manzanas of corn, 65 manzanas of sugarcane, and 24 manzanas of cassava (25). Most of the land was in pasture or forest.

The dry season is less pronounced in Acosta than in Alajuela. Only January averaged less than 50 mm of rainfall during the period from 1961 to 1965 (64). The heavier and more uniform rainfall brings about a slight reduction in quality from that which the elevation of the area would suggest. Quality falls into the Hard Bean category (2). Leaching and erosion have reduced the natural fertility of the area.

Traditional practices have persisted in the Acosta area. The

district coffee yields were 64 percent of the national average. San Ignacio produces only 0.67 percent of the Costa Rican coffee; however, conditions are similar in other districts along and beyond the southern rim of the Central Valley. The area was included in the study to represent a poorer coffee-growing region which fits a definition of "marginal land" based on low output per unit of land and labor (27).

Farm 13 is a large coffee producer in Acosta. The farm covers 101.5 manzanas of rugged land averaging 1,100 meters elevation. Coffee occupied 90 manzanas and 1.5 manzanas were planted to oranges. The remaining ten manzanas were used to produce a joint crop of corn and beans. Labor was supplied by four male family members and thirteen hired men and one hired woman. Fixed costs were estimated at ₡47,496 and ₡51,500 were available for annual expenses. The net farm income was estimated at ₡66,878. This farm was chosen to represent large farms with poor soils.

Farm 14 is a medium-sized unit in Acosta located on rough land at 900 meters elevation. The size is 16 manzanas of which 7 manzanas were planted to coffee. There were 4 manzanas of oranges and 5 manzanas of corn and beans reported. The farm had 3 adult male family workers. The fixed expenses are ₡1,184 and ₡5,945 were available for annual operating expenses. The estimated net returns were ₡11,446 on this middle-sized farm with mixed cropping.

Farm 15 is a small Acosta unit on nearly level ground at 1,100 meters. It had 2 manzanas planted to coffee with interplanted orange trees supplementing farm income. The farm family supplied the labor of one man and three women. The fixed costs were estimated at ₡424. Credit and operating capital totaled ₡825 for short-run expenses.

The farm reported a net income of ₡1,003. However, the costs included an abnormally high number of new plants which suggested that an investment was being made. The net income estimate was therefore adjusted to ₡1,403.

Farm 16 is a second small farm in Acosta. The farm contains 6.5 manzanas of which 1.5 are planted to coffee with scattered orange trees. The labor was supplied by one man and one woman of the owning family and also a hired man and a hired woman. The fixed expenses totaled ₡2,988 and ₡675 were available for variable costs. The farm income was estimated at ₡1,339. This farm was considered typical of the small, mixed-crop farms of the area.

The Linear Programming Model

It would be presumptuous to claim that a study using one year's data and many imported or estimated production coefficients would be sufficiently accurate to permit the calculation of optimal management plans to the five decimal places provided by the University of Florida computer. However, the lack of a high degree of accuracy of data should in no way be a deterrent to the use of the computer to solve problems of a practical nature.

Linear programming is now widely used as a farm management analysis technique. However, in this particular study the emphasis is put upon policy rather than production analysis. The input and output coefficients may or may not represent true possibilities for the farm groups studied. However, they do represent the expected possibilities open to those farmers based upon limited experimental data, reported experience, and the opinions of the extension agents who advise them. Therefore, the model attempts to predict how it would pay the farm

decision makers to react to a series of policy measures given certain expected cost-output relationships for coffee and various alternatives. The results were expected to provide implications with respect to actions that farmers would be likely to take in response to program changes.

The linear programming model is a computational method used to minimize or maximize a linear function given a series of linear inequalities as restraints (33, p. 7). Net returns or profits were maximized for each farm studied. The matrix in each application of the model was comprised of the following sub-matrices: A production sub-matrix was made up of input-output coefficients for the monthly land and labor requirements, capital requirement, rotation requirements and coffee land requirements for the various crop production activities. Costs were included as negative entries into the profit row and yields were included as negative entries in transfer rows. A selling sub-matrix consisted of price coefficients in the profit row and unitary entries in the product transfer rows. A transfer sub-matrix was comprised of coefficients of columns representing labor purchasing, coffee planting, coffee destruction, borrowing, long-term credit and fixed cost transfer.

The matrix included input coefficients for the monthly land and labor requirements of the various enterprises. Additional restraints included operating capital, rotational limitations, and coffee plantings. Production coefficients were entered in transfer rows to be sold via selling enterprises. Monthly labor purchasing was limited to a 2 to 1 ratio of adult male labor which allowed two temporary workers to be hired for each permanent employee as a labor

supervision restraint. Planting and destroying coffee trees were entered with cost and investment coefficients. New investments were not limited but were given a cost through a borrowing column. Coffee harvesting was handled by using both contract and family labor harvesting. A special family labor restriction was used during the harvest months. Excess labor was allowed to be sold during the coffee harvest but not at other times.

Parametric programming was used to estimate the effect on optimization when changes in policy and in production levels occurred. Coffee yields were programmed downward 50 percent. Coffee price was reduced $\phi 100.00$ and printouts were made at $\phi 5.00$ intervals. A continued annual payment for coffee removal was considered. Operating capital was reduced 70 percent. A special credit row allowed the operating capital requirements of expandable alternative crops to be reduced. Credit was increased. A two-price system allowed differentiated coffee prices to reflect returns to coffee sold in traditional and in new markets. Prices and yields of certain alternatives were moved upward and downward. All new crops were excluded by downward price manipulation. Family labor and hired labor were permitted to be shifted off the farm. Lastly, higher yielding coffee alternatives were allowed to enter with additional investments.

The farms selected were analyzed using linear programming to maximize profits for a one-year period. Annual crops were considered using land, labor, and operating capital coefficients taken directly from enterprise budgets.

Enterprises requiring new long-term investments were considered using maintenance costs and return estimates for an annual period

after commercial production would become stabilized. Establishment costs of permanent crops were calculated with opportunity costs included as part of the investment to be considered using interest charges. Thus, loss of income during the establishment period was estimated and added to material and labor costs making up the investment calculation. The cost of making this investment was computed using a low interest rate of 6 percent which assumed special long-term credit subsidies for permanent crops.

The coefficients for intermediate length enterprises were calculated by summing the budget entries for the years of duration of the crop. Thus the unit used was a "planting unit" or that area planted each year and assumed an averaging of resource use over time. This admittedly limited the strategy of cropping plans to be considered, but this simplification greatly reduced costs of analysis while coinciding with the generally followed procedure of "evening out" inputs over time.

Presently established long-term coffee enterprises were entered into the matrix without calculating investment costs. Additional plantings were allowed but were associated with long-term interest charges on the investment.

Depreciation of the investment was not considered for the permanent crops. If the annual expected returns surpassed returns of other alternatives after interest costs were paid on the investment, then it was assumed that the investment was an addition to net worth which offset the original expenditure.

To further clarify the model, the mechanics of the less conventional manipulations are given in more detail. Operating capital was taken as a short-term credit restraint. All annual costs except in-

terest, transportation, and contract harvesting were used to determine the requirement for operating capital of each enterprise. Reported expenditures were taken as the row constraint for each farm.

Rotational restraints for annual crops were handled in the following manner: Total farm land was used as the constraint on the right-hand side. Each manzana of permanent crop used one unit of the rotational limitation. Then the crops requiring rotation received a coefficient equal to the minimum number of years during which only one crop would be permitted. A coefficient of one allowed an average of no more than one crop of beans per year. A coefficient of five allowed only one crop of cucurbits in five years. This restraining row cannot be used to set up the sequence of a rotation but does insure that the optimal solution does not include a degree of crop specialization contrary to required pest control practices.

Coffee plantings were used in three different constraining rows. To insure that new coffee land was charged the cost of planting coffee, maximum coffee land was set equal to or less than reported coffee land plus land newly planted to coffee. To account for tree removal costs of shifting land from coffee to other uses, another row set optimal coffee land equal to or greater than reported coffee land plus the land from which coffee was removed. A third constraining row set coffee removal at no more than reported coffee land to block irregular possibilities as payments were made for coffee removal in parametric operations.

Coffee harvesting requirements were handled in the following manner: Coffee selling enterprises were given a coffee harvesting requirement. An option was given for harvesting, allowing either

contracted labor or family labor to be used. The first means of harvest used a cost of ₡40.00 per fanega. The utilization of family labor used monthly labor resources and family labor resources at a level of four or five hours per fanega each month during the harvest period.

Parametric programming was used to anticipate the effect of various policy manipulations and to test the stability of the optimal plan in the face of certain price and yield changes.

The use of selling enterprises made the programming of price changes straightforward. A change row in the matrix contained coefficients of change. Programming cards determined the magnitude of change and the frequency of printout. Thus, the solution of the program was continually re-evaluated as additions or subtractions were made to coefficients in the objective function. $C_j' = C_j + X_j$ (N) where C_j' is the new price, C_j is the old price, X_j is the change row entry and N is the parametric multiplier ranging from 0 to a given maximum. Prime decline used a negative X_j value.

Yield changes were programmed using "PARAROW" parametric additions or subtractions. The solution of the program was re-evaluated as a changing multiple of change row coefficients was added to the coefficients of a designated transfer row. $P_j' = P_j + X_j$ (N) where P_j' is the changed yield, P_j is the old yield, X_j is the change row coefficient and N is the parametric multiplier. Proportional changes of several enterprises producing the same product was allowed by setting $X_j's = P_j's$.

The effect of special credit facilities to finance the production of the non-traditional cash crops was handled by a parametric reduction of the use of normal operating capital of the favored enterprises.

This assumes a selective policy of credit expansion for crop diversification. The "PARAROW" operation was mechanically like the yield change procedure. $K_j' = K_j + X_j (N)$ where K_j' is the new credit coefficient, K_j is the old credit coefficient, X_j is the exchange row coefficient and N is the parametric multiplier. With (X_j) equal to K_j and N equal to one, K_j' equals zero and the credit needs of favored crops are all supplied by the new unrestricted source of credit.

The effects of a reduction of credit were analyzed by using "PARARHS" procedures. The parametric programming of the credit constraint, a right-hand side value, used an exchange column coefficient set equal to the credit constraint. The parametric multiplier ranged from 0 to .70. This assumed 30 percent farm supplied operating capital as the lower limit of practical credit reduction. $K_r' = K_r + (-X_r) N$ where K_r' is the modified credit constraint, K_r is the old credit constraint and $-X_r$ is the coefficient of the exchange column. In a similar manner, an increase in credit was programmed with available credit being increased up to \$2,000 per manzana.

A programming procedure was devised to evaluate the effect of differentiating farm prices between sales into the new and into the traditional market. Since the new market price was roughly 25 percent below the traditional market price and the new market took roughly 25 percent of total output, the differentiated new market price was set at 80 percent of the current farm price and the traditional market price set at 106 2/3 percent of the current farm price. The coefficient of the new market coffee selling enterprise was not changed by the parametric additions. The traditional market selling

enterprise was given a functional coefficient of zero. The exchange row included coefficients for both the traditional market selling enterprise and the current coffee selling enterprise. The former was the estimated price that coffee would receive were it sold only in the traditional market. The latter was a negative price coefficient devised to exclude the average or current coffee selling activity as the sale via the higher priced selling enterprise was permitted.

Table 1. Partial matrix of coffee selling activities

	Averaged market	New market	Traditional market
Profit	200	1.60	0
Coffee transfer row	1	1	1
Limit to traditional market	0	0	1
Change row	-200	0	213 1/3

By referring to Table 1, it may be seen that parametric changes will first block selling in the averaged market and then permit selling in the traditional market. Sales in the traditional coffee market were limited to 75 percent of the reported output of each farm. The single printout of the solution was called when the values of the change row were added to the functional. The price coefficient for the averaged market was reduced to zero. That of the new market was unchanged and that of the traditional market was increased to 106 2/3 percent of the averaged price. In this manner the marginal return for additional coffee on each farm was set equal to the

corresponding marginal returns to the country and each farm would receive a price based upon new market returns for production in excess of the quota. In this manner, the benefits of higher prices in the traditional markets could be passed on to the producers without increasing incentives for overproduction.

The payment for the removal of coffee trees was programmed as a continuing payment made after the removal of coffee trees. An activity for coffee destruction was given an annual cost to force the payoff for coffee removal to be made in five years. Subsidizing coffee tree removal was programmed with a change row entry in the coffee tree destruction column. Payments from 0 to ¢1,800 per manzana were covered with printouts on ¢200 intervals. The calculation of payments equal to 20 percent of coffee's gross returns per manzana was made using interpolation where there was no change in resource use between the 20 percent payment and one of the printed outputs. When the straight-line interpolation could not be made, the problem was re-run with output demanded where the payment was equal to 20 percent of the gross returns to coffee.

Algebraically, $C_d' = C_d + X_d (N)$; where, C_d' is the return for destroying one manzana of coffee, C_d is the cost of destroying one manzana of coffee, X_d is the unitary exchange row entry and N is the parametric multiplier which represents varying levels of subsidy payment. In addition, the exchange row contained a large negative entry in the coffee planting column to block new coffee plantings if payments were made for coffee removal.

The effect of outside employment on family income was studied using parametric changes of the objective function. In an original

matrix, a column represented the reduction in monthly labor supply as a man left the farm for other employment. Additional entries represented the effect on the monthly hiring of temporary labor and monthly family labor for coffee harvesting. Also, a constrained row restricted movement to adult male family members. Since this use of resources received no returns it would not come into the initial optimal solution. Then returns were entered with parametric changes to record the response of income and output as outside opportunities increased to the level established by minimum legal wage laws. Therefore, $C_w = X_w (N)$; where, C_w equals outside wage returns per man, X_w equals the exchange row entry of the legal minimum wage, and N equals the parametric multiplier ranging from zero to one.

The effect of moving permanent employees to other jobs was handled in a similar manner. The only differences were that the exchange row coefficient was smaller, reflecting the part of the calculated permanent labor costs that are not cash expenditures, and entries for family coffee harvesting were not applicable since permanent employees are paid by the fanega for harvesting coffee. Movement was restricted to adult male employees.

Parametric changes in the interest rate for long-term investments were programmed with the same procedure as price changes. The cost of borrowing was increased from 6 to 20 percent of the investment. An investment row requires that money be supplied to meet investment requirements via a borrowing activity. An exchange row entry is multiplied by an increasing number so that $i' = i + X_i (N)$; where, i' equals the new interest rate, i equals the old interest rate, X_i equals the change row element in the borrowing column and N equals

the parametric multiplier. This procedure was used to evaluate the effect of interest rate changes on the stability of resource use.

The fact that economic development is a long-term phenomenon may stimulate objections to the use of a model maximizing returns to a single year. With more work and more computer expenditures, it would have been possible to build a growth model maximizing returns over a period of five, ten, or even twenty years. Such a study could quite dramatically illustrate the gains to be derived from more investment capital, cheaper interest rates, longer term loans and the cumulative effects of modern inputs.

However, there is a danger in trying to extract too much information from limited data. The data were collected with interviews in a single year. The effects of one crop on successive crops are not yet known. Any errors in reporting, interpreting, and evaluating the data will be multiplied not only by the simple coefficient of time but also by complex coefficients reflecting the fact that each year's output becomes part of the next year's inputs.

To be accurate, the long-term growth model also requires correct predictions of the interest rates and future credit availability. An even more difficult prediction centers on technology. Will yields remain constant? Will they remain proportional if they change? Will some resources become outdated? If changes occur, when will they occur? Will technological changes be accompanied by changes in factor prices and product prices? The common economic practice is to avoid these questions by assuming constant technology. This excludes a chief source of growth from the growth model.

Those crops of greater economic importance are likely to receive the greater agronomic research. This means that specialization or monoculture is likely to be encouraged by technological change. Also, larger commercial farms can be expected to change faster than small, near subsistence units. Thus, while it is possible to predict the direction or tendencies of certain differences in crop technology, the magnitude of those differences will be difficult to estimate.

These statements should not be taken as a general argument against long-term planning or programming. Such an attack on problems is worthwhile despite the inherent difficulties. However, with the data and prior knowledge available, it was decided that more practical information could be gleaned from a single-year model having more alternatives.

The Enterprises and Restraints

One of the basic assumptions of the linear programming model is that a finite number of alternatives and resource restrictions exist. The number of combinations of factors must be limited but the degree of limitation is arbitrary and depends upon the use that is to be made of the model.

In this study, the objectives were to compare coffee with alternative enterprises. A number of different processes or methods of growing coffee and different processes for some of the alternative enterprises were considered because, with different farm resources and parametric changes, one particular technology was not obviously superior to the others. Also, an averaging of inputs and yields is not particularly meaningful since distinctly different technologies

related to differences in yields are known to exist. In the decision as to the number of processes for an enterprise the availability and the accuracy of the data were taken into account. Activities were chosen to represent different intensities of the use of labor and operating capital as well as different levels of modernization. Activities found on the poorer farms were included in the better farms' alternatives. However, the activities requiring high levels of technical skills were blocked for the poorer farms in the initial solution and were considered only in special parametric procedures.

The activities were coded from budget data supplied by the extension agents and also from the budgets of the agricultural credit reports of the Banco Nacional de Costa Rica and the Banco de Crédito Agrícola de Cartago and the Ministerio de Agricultura y Ganadería. These sources supplied data concerning material inputs, labor hours and timing of various work operations and expected yields of selected enterprises in particular areas. In addition, activities were synthesized from foreign input-output data which were modified to anticipate Costa Rican conditions by adapting labor requirements for particular work operations from currently grown crops. Research studies of the Universidad de Costa Rica were used to supply data for certain horticultural activities.

Activities based on foreign or small research plot data were entered with what was believed to be "conservative" yield estimates. The results of plot trial yields were estimated by using the lowest variety yield which was not significantly different (at a 5 percent level) from the highest variety yield.

One problem that arose was the fitting of the labor requirements within the monthly labor constraints. In most cases the farm enter-

prise reports placed the labor for each work operation within a given month; however, in a few instances the reports spread work over a two- or three-month period. Overlapping time periods would have made the computations much more costly. Instead, two processes were sometimes used for timing the input use of labor, and the labor uses in other cases were arbitrarily placed in months so as not to compete with coffee harvesting.

The use of operating capital and short-term credit was handled together to avoid antagonizing the cooperating farmers. The extension agents felt that loan information was personal and requested that this section be deleted from the original forms. Therefore, total short-term expenditures were used as the right-hand-side constraint for the operating capital and credit row for each farm. This assumed that the farmers were using as much bank credit as they could get. As a result, the credit situation is oversimplified in the model, but the complications of overborrowing for consumption or non-agricultural uses are thus avoided. These complications would be difficult to identify using interviews since some common practices are of questionable legality.

For the Palmares and San Ramón areas, the programming matrix was made up of 81 rows and 94 columns. The rows included 12 for monthly labor use, 12 for monthly land use, 12 for temporary monthly labor use, 4 for monthly family harvesting labor, 1 for operating capital and credit use, 3 for tobacco contract, 1 for investment, 1 for fixed expenses transfer, 14 for product transfer, 3 for coffee land, 1 for coffee harvesting, 1 for corn shelling, 1 for land transfer, 1 limiting row for traditional coffee market sales, 2 crop

rotation requirement rows, 2 labor movement rows, 9 exchange rows for parametric changes, and 1 profit row.

The columns included 10 coffee growing activities, 9 tobacco growing activities, 8 corn growing activities, 4 joint corn and bean growing activities, 4 bean growing activities, 2 sesame growing activities, 2 castorbean growing activities, 5 dairy activities, 2 beef activities, 1 peanut growing activity, 2 buckwheat growing activities, 1 chickpea growing activity, 1 pigeon pea growing activity, 1 mixed crop producing activity, 1 annual to monthly land use transfer activity, 3 coffee selling activities, 3 tobacco selling activities, 8 grain selling activities, 1 calf selling activity, 1 milk selling activity, 4 monthly labor selling activities, 2 yearly labor selling activities, 12 temporary labor hiring activities, 1 borrowing activity, 1 coffee planting activity, 1 coffee-destroying activity and one fixed cost transfer column. A listing of the row entries of each of the activities programmed is given in the Appendix.

Only farms 1 and 2 were programmed to allow the use of all the activities coded for the area. Farms 5, 6, 7 and 8 were not using the same high level of technology as that found on farms 1 and 2. The two most productive coffee-growing activities were blocked by removing the coffee production transfer card. A change row entry was substituted and an investment entry added so that a parametric procedure would evaluate the acceptability of the change if education were to permit its occurrence.

Farms 3 and 4 were below-average coffee producers. They were permitted to use only the least profitable coffee-growing activities of the area. Again a parametric procedure allowed higher production,

assuming that education and long-term investment could make the higher yields possible.

In the Alajuela area, the matrix was composed of 94 rows and 87 columns. The rows included 12 for monthly labor, 12 for monthly land, 12 for temporary labor, 4 for monthly family labor for coffee harvesting, 1 for investment, 1 for operating capital, 1 for coffee harvest, 19 for product transfers, 4 for rotation limits, 1 for yearly land, 1 for fixed expenditures, 3 for coffee land, 2 for off-farm labor movement supply, 1 for limiting sales in the traditional coffee market, 12 for changes in parametric modifications and 1 for profit.

The columns included 9 coffee growing activities, 1 lime growing activity, 1 orange growing activity, 3 corn growing activities, 2 corn-bean growing activities, 3 bean growing activities, 1 pineapple growing activity, 1 strawberry growing activity, 6 sugarcane growing activities, 3 cassava growing activities, 2 cucumber growing activities, 2 sweetpotato growing activities, 2 tomato growing activities, 2 sweet pepper growing activities, 1 peanut growing activity, 1 chickpea growing activity, 1 buckwheat growing activity, 1 pigeon pea growing activity, 1 dairying activity, 3 coffee selling activities, 16 alternative product selling alternatives, 2 coffee harvesting activities, 2 all-year labor selling activities, 4 monthly labor selling activities, 12 monthly labor hiring activities, 1 fixed cost transfer column, 1 land transfer column, 1 coffee planting activity, 1 coffee destroying activity, and 1 borrowing activity for long-term credit.

With the exception of farm 9, the two highest-yielding coffee activities were blocked for the original solutions and allowed to

enter with parametric changes. Lime and strawberry selling activities reflected prices estimated for processing use. These prices were ¢13.00 per quintal for limes and ¢1.00 per pound for strawberries. These prices were conservative estimations for the Central American Common Market and were programmed both upward and downward to fit conditions of the fresh market and world market, respectively. Actually, average current prices are much higher in the local fresh fruit markets; however, these high prices would be unstable in the face of any sizable change in quantity.

Tomatoes and sweet peppers were also priced for processing use. The price used for sweet peppers was lower than the quoted contracting price because pepper contracts were tied to tomato contracts.

Cassava, cucumbers, and sweetpotatoes were priced at the reported market lows of the two years prior to the survey. Parametric changes lowered vegetable prices to levels competitive in the world market.

While substantial changes in technology would be required if the fruit and vegetable activities replaced coffee, these changes were permitted in the model because the extension and research facilities seem capable in the zone. The experiment station of the Universidad de Costa Rica is located in the zone and specializes in horticultural crops. It is easier to sell new ideas when they have been tested under local conditions and the results are being applied by the agronomists on their private commercial farms.

In the study of the Acosta area, the matrix contained 65 rows and 60 columns. The rows included 12 for monthly labor, 12 for monthly temporary labor supply, 1 for investment, 1 for operating capital, 3 coffee land limiting rows, 5 for monthly family labor for

harvesting, 1 fixed expenditure transfer row, 1 row limiting coffee sales to the traditional markets, 1 coffee harvesting row, 1 yearly land supply row, 9 for product transfers, 2 for off-farm labor movement and 1 profit row.

The columns included 7 coffee growing activities, 2 joint coffee-orange growing activities, 3 joint corn-bean growing activities, 1 blackberry growing activity, 2 orange growing activities, 2 beef producing activities, 5 dairy activities, 1 lime growing activity, 3 coffee selling enterprises, 8 selling enterprises for other farm products, 2 coffee harvesting activities, 5 monthly labor selling activities, 12 monthly labor hiring activities, 1 fixed cost transfer column, 2 yearly labor selling activities, 1 coffee planting activity, 1 coffee destroying activity, and 1 borrowing activity for long-term credit.

Since the growing periods for all the crop activities programmed for Acosta overlapped, land was programmed as a single resource instead of being divided into monthly intervals of use.

Ecologically, Acosta is poorly suited to annual cropping. Corn and beans were included because they are traditionally grown. Other annuals were excluded from the area's model in order to conform with conservation requisities.

The coffee yields in Acosta are less than the yields of the other two areas. Poorer technology may have resulted from relative isolation in past years. However, lower fertility is chiefly responsible for lower yields. Two higher-yielding coffee growing activities were blocked in the initial solution but were allowed to enter in a parametric procedure representing technological change.

Two price levels were used for fruit selling in Acosta since

selling opportunities could be greatly affected by the nearness to market outlets. Risks and transportation costs would be reduced if a processing plant were built in the area. Prices were discounted 30 percent for limes, 25 percent for oranges and 50 percent for blackberries when local outlets were not anticipated.

In calculating production costs for the production activities, short-run interest charges of 8 percent were added to the costs of materials.

The Sources of the Budgets

It was necessary to use agronomic data from several different sources to construct the matrix of input and output data used in the study. Farm resource information and input-output data were provided by the extension agents in each area analyzed. The extension agents collected data from the farms they considered typical of the various farm size and type classifications found in their particular region. Most of the budgets for coffee, corn, beans and sugarcane were provided by the cooperating extension agents. These were supplemented by data provided by the Banco Nacional de Costa Rica (18) and the Banco de Crédito Agrícola de Cartago (58).

San Ramón and Palmares farms were grouped together in the analysis. Ing. Efraín Abarca collected data from San Ramón including budgets used in the most productive coffee activities yielding 27.6, 25.7 and 20.0 fanegas per manzana. Ing. Danilo Zamora collected data from Palmares farms which reported coffee yields of 19.0, 15.0, and 5.3 fanegas per manzana. The best yields included herbicide use, three applications of fertilizers, insecticide use and moderate pruning and weeding labor. Common practices included the use of

fertilizer and insecticides and gave yields above the national average. Coffee activities using traditional methods were programmed from data of the Banco Central de Costa Rica (7). Moderately heavy labor with few purchased inputs produced a yield of 9.0 fanegas per manzana. An activity of semi-abandoned coffee was based upon conversations with Ing. Hugo Castro. Yields up to 4.0 fanegas per manzana were obtainable without purchased inputs other than sacks and without labor except harvesting and enough weed cutting to allow the pickers to walk.

The extension agents' farm budgets also included corn and bean activities. Common corn yields ranged from 13.3 to 40.0 quintales per manzana. Higher-yielding activities were programmed from data furnished by Ing. Walter Villalobos from 4-S Club plots at Santa Ana. Yields were modified to 70.0 quintales per manzana maximum to correspond with the reportedly poorer growing conditions. The moderate use of fertilizer and insecticide, as reported in the worksheets of the Banco Nacional, yields 48.0 quintales (18).

Bean activities were based on budgets from the following sources. Modern technology yielded 18 and 20 quintales per manzana according to budgets derived from a ministry of agriculture publication (51). The Banco Nacional supplied budgets of low-yielding bean crops from broadcast planting that yielded only 4.2 quintales per manzana and traditional methods that yielded 9.6 quintales per manzana (18).

Joint corn and bean production activities were programmed allowing combinations of the average and poorer yielding corn and bean activities commonly grown together.

Tobacco growing activities were programmed from budgets of the Junta de Defensa del Tabaco (36) and the Banco Nacional (18). Yields

ranged from 18 to 20 quintales per manzana but the budgets from the Banco Nacional used lower levels of inputs.

Sesame was programmed using a budget of traditional methods supplied in Ospino's work (58). A budget of modern practices for growing sesame were synthesized using data from the United States (21, 38, 39). An estimate of yield expectations was placed at 20 quintales per manzana despite reported yields up to 35 quintales per manzana.

The castorbean production activities were based on synthesized budgets based upon foreign agronomic data (20, 72). Yields were estimated at 34 quintales per manzana.

The traditional activities for producing dairy were based upon reported budgets from Atenas by Ing. Adrian Prado. More intensive dairy production activities were based on budgets from Heredia supplied by Ing. Carlos Norza. Production ranged from 400 to 1,200 bottles of milk per manzana with extensive land use and from 1,000 to 2,000 bottles with more intensive operations.

An extensive beef calf producing activity and a moderately intensive beef producing activity were budgeted by Ing. Ramón Castro in San Carlos with one cow per 5.0 manzanas in the first case and one cow per 1.5 manzanas in the second. Much higher range productivity was reported in studies made in Puerto Rico (14). However, the cost of production would not be covered by Costa Rican prices.

Pigeon pea production activities were based on budgets synthesized from agronomic data chiefly from Hawaii (31, 40) modified by Costa Rican recommendations (50). Reported yields reached 20 quintales per manzana.

Buckwheat was included as a catch crop. Yields were programmed at 8 and 20 quintales depending upon the time of planting. Reported production in Mexico (70) and Ceylon (4) showed that this crop could be grown in tropical countries.

A peanut production activity was included although part of the soils may not be well adapted. Yield was programmed at 20 quintales per manzana as Banco Nacional data from Alajuela were used to synthesize a budget.

Chickpeas were included as a dry season catch crop. Cultivation is similar to beans (47) and the yield expectations are 5 quintales per manzana.

A mixed crop enterprise was synthesized from other budgets combining corn and legumes with high labor inputs.

Coffee price was determined by an unweighted average of the prices paid by the beneficios in Palmares in the 1966-67 crop year. Corn and bean prices were reported by the extension agents. Peanut and sesame prices were included in the credit worksheets of the Banco Nacional (18). Castorbean price was computed from the world dollar price. Buckwheat was priced arbitrarily low to reflect probably limited acceptance as a feed grain. The chickpea and pigeon pea prices reflected estimated wholesale prices based upon retail prices in San José as compared with beans.

In the study of the Alajuela farms, budget data on coffee production were supplied by Ing. Guillermo Montenegro. Yields ranged from 25 fanegas per manzana on the best farm to 16 fanegas per manzana on the poorest farm. The maximum yield permitted without technological change modifications was 20 fanegas per manzana except on farm 9 which had already adopted modern production techniques. Traditional and

semi-abandoned coffee production activities were included with the same coefficients used in the Palmares-San Ramón matrix.

Lime production was programmed with input-output data synthesized from Florida sources (42). Yields were 400 quintales per manzana. This approximates a U. S. yield of 462 bushels per acre. Costs of establishment used U. S. costs but annual labor costs were modified by data from Costa Rican orange production budgets.

The orange production activity was programmed from data of modern orange production in Guatemala (49) and Florida (28). Yields vary with the age of the trees but an estimated yield of a mature grove was taken at 1,020 cien (hundred fruit). This approximates 300 boxes of fruit per acre.

Tomato production activities covered common and modern producing techniques. The common yield of 11.25 tons per manzana was reported in a budget worksheet of the Banco Nacional (18). Experimental results of agronomic trials show yields that surpass 20 tons per manzana (26).

Corn production activities were based upon 4-S Club budgets which reported yields of 90 quintales per manzana and upon extension agent reports of corn yielding 60 quintales per manzana. Corn production was also programmed in joint activities with beans where the output of 48 fanegas and 20 fanegas of corn was produced jointly with 18 and 4 fanegas of beans in budgets supplied by Ing. Guillermo Montenegro.

Bean production was programmed with three distinct levels of technology. Modern inputs yielded 20 quintales per manzana (51), broadcast beans yielded 5 quintales per manzana and traditionally planted beans yielded 10 quintales per manzana (18).

The strawberry producing activity used Florida production data (12) modified by incomplete data from Alajuela and Heredia farms. Yields were programmed at 250 quintales per manzana. This approximates 14,600 pounds per acre. Good California yields, for comparison, ranged from 48,000 to 60,000 pounds per acre (43) and Israel increased its average yields from 3,000 to 10,350 pounds per acre in six years (35).

Sugarcane production activities were programmed from budgets supplied by the Banco Nacional (18) and the extension agency. Production ranged from 60 tons per manzana to 100 tons per manzana per harvest. In a period ranging from 38 to 48 months, three harvests were made. Production and inputs were totaled for the entire periods.

Three cassava producing activities were programmed. Traditional methods were represented by a budget which yielded 150 quintales in a 21-month growing period (18). Intermediate yields were received by a budgeted production lasting two years (58). Higher yields, 275 quintales per manzana, were programmed with more modern inputs and longer growing period of 26 months (26). Total production per month increased with age but quality declined.

Cucumber production activities represented different timing of modern techniques based upon agronomic data furnished by the Alajuela experiment farm (52). Yields were 140 quintales per manzana.

The sweetpotato production activity based on modern inputs (5) yielded 300 quintales per manzana which tripled the yield of traditional methods reported by the Banco Nacional (18).

A peanut producing activity utilized a budget reported by the Cartago bank (58). Yields of 25 quintales per manzana were expected.

Pigeon pea, buckwheat and chickpea production activities were included, based upon the same sources as used for the Palmares-San Ramón study.

Prices were based on an unweighted average for coffee, reported lows of vegetable prices, and estimates of potential industrial prices for tomatoes, peppers, strawberries and citrus. Since the projected horticultural marketing assumed much greater volume than current sales, price predictions were lower than average prices but subject to considerable error.

In the study of the four farms in Acosta, coffee production budgets were supplied by Ing. Rodrigo Cavallini of the San Ignacio Extension Agency. The better methods used fertilizer or other purchased inputs and yielded 10 fanegas per manzana which was considered high for this region. Traditional methods yielded six fanegas and used small quantities of fertilizer and heavy labor inputs. Coffee was grown with oranges and bananas on some farms with poor yields of both coffee and fruit. Coffee yielded five and six fanegas and oranges yielded 1,000 to 3,000 fruit per manzana on neglected trees.

An activity used to program the possibilities of technological change was supplied by Edwin Marín of the Oficina del Café. He budgeted production yielding 14 fanegas per manzana in an adjoining district. An activity was also included representing semi-abandonment and yielding only two fanegas per manzana.

A high yielding orange producing activity was included and based upon data taken from foreign sources (28, 49). This activity yielded 102,000 oranges compared to 53,300 oranges per manzana produced on a farm in Acosta.

Corn and bean production was reported with low to very low yields. Joint cropping produced 29, 6.4 and 16 fanegas of corn combined with 11, 9.6 and 6.6 fanegas of beans.

The same beef and dairy production coefficients used in the Palmares study were included in the matrix.

Lime production was included with a yield of 400 quintales per manzana based upon Florida data (42).

The inclusion of a blackberry producing activity also was based upon a composite of information from Florida (65) and Costa Rica. Yields of 16,000 pounds per manzana were anticipated.

Assumptions of the Model

There are certain assumptions and limitations of the model which should be clarified before the results are interpreted. Linear programming uses profit maximization within a set of constraints as a single criterion for allocating resources. This would deviate from actual practice especially in those cases where the magnitude of gain is so slight as to not make a more complicated program worth the trouble when compared to a simpler, more easily managed plan of operations. Also, the model does not take uncertainties and risks into account. Risks, that may be either real or imagined, enter into farm decision making. Yields and prices vary from year to year. The farm operator will actually be interested in maximizing profits only within some range of acceptable risk.

The model forces all decisions to be made at once. Since it is a static model, growth possibilities are not taken into account. This is particularly troublesome in the case of short-term credit and

operating capital restriction. Because of this feature, the model is conservative insofar as new resources are not permitted to be generated over time.

All units are considered divisible. This does not cause a problem except in the case of cattle and labor movement. Theoretically, part-time employment could explain fractional units of labor movement.

RESULTS

Optimal Cropping Plans

In general, cropping patterns determined with the initial linear programming model did not greatly differ from the reported practices. With one exception, land was fully utilized during at least part of the year. Unused permanent labor was often available except during coffee harvest. The restrictions on hiring temporary day-wage labor were generally not constraining. Where horticultural crops were considered, operating capital was restrictive. This restriction occurred also on the smaller, poorer coffee farms. Marginal returns to short-term credit, calculated by using reported expenditures as a base, were either zero or well over the established interest rate. Parametric changes found coffee production to be stable in the face of moderate coffee price and yield decreases but responsive to technological improvements and credit manipulations. Changes in the availability of credit, the interest rate, the labor supply, and product prices had a much greater effect on the allocation of resources among the various alternative crops than they had on coffee production. A brief summary of optimal resource use will be given for each of the 16 farms.

Farm 1

The optimal solution of this coffee-tobacco farm coincided with the reported production. Two manzanas were planted to thinly spaced

corn and tobacco and three manzanas were used to produce coffee. In addition, two manzanas of buckwheat were planted in the dry season. The net returns (¢19,781) fell slightly below the farmer-estimated returns (¢22,500) because the model included extra labor costs and lower corn prices. Land and burley tobacco contracts were limiting rows with marginal values estimated at ¢4,069 and ¢215, respectively. Temporary labor was hired in October and January. Permanent labor was fully utilized in May and October as well as from November through February where the model permitted coffee harvesting to exhaust the labor supply. A slight excess (¢81) in operating capital occurred.

Farm 2

The second farm from San Ramón was a small specialized coffee producer. The optimal solution for the linear programming model derived for this farm situation also produced only coffee. Net returns in the model were ¢18,024 compared to ¢15,250 calculated from the farmer report. The model permitted the use of a higher-yielding coffee activity which proved slightly more profitable than the technology actually used. With tobacco activities blocked, the only effective constraint was land. Permanent labor was exhausted only from November through February when coffee harvesting utilized all the labor. The farm optimal solution used ¢3,157 of ¢4,000 available capital and credit. There were 193.2 fanegas of coffee produced.

Farm 3

This farm produced good coffee yields with very high costs. The model permitted traditional coffee activities on this farm but the five best coffee-producing activities of the region were blocked. The optimal solution contained less-intensive coffee production,

more-intensive use of the non-coffee land, and no reduction in coffee acreage. Coffee output was reduced 25 percent from the reported output. This change was accompanied by an increase in net income from ₡34,130 to ₡35,543. The optimal plan made heavier demands on management with seven producing activities instead of three. Sales included 750 fanegas of coffee, 52.8 quintales of tobacco, 108.4 quintales of corn, 49.1 quintales of beans, and 16.3 quintales of sesame.

The flue-cured tobacco contract row was exhausted as all three manzanas permitted for tobacco were planted in the farm model. Permanent labor resources were exhausted in all months except May and October. Coffee harvesting exhausted the labor supply during November, December, January and February. Temporary labor was hired in March, June, July, August and September.

The optimal plan used less than ₡45,666 of a ₡71,100 operating capital and credit constraint.

Farm 4

The fourth farm studied produced coffee and flue-cured tobacco. Tobacco was the chief money earner with coffee grown to supplement income with very low labor inputs. The linear programming model of this farm situation resulted in considerable changes in resource use. Coffee output was increased from 80 to 225 fanegas and tobacco production was reduced from 90 to 46.8 quintales. In addition, corn, beans, and mixed crops were substituted for tobacco. Sales also included 36.7 quintales of corn, 59.9 quintales of beans, 2.6 quintales of pigeon peas, and 81 pounds of chickpeas. Net returns in the model situation were ₡31,667 which greatly exceeded the ₡14,700 estimate of income under reported resource use.

The model used all available land from July through January, all available operating capital and credit, and all permanent labor in April, June, July, August and the harvest months from November through February.

Temporary labor was hired in January and August. Family coffee harvesting was limited by the family labor supply in December. Hiring labor was not constrained by monthly supervisory limitations which allowed two temporary workers for each family or permanent employee. The tobacco contract allotment was not exhausted.

Farm 5

The fifth farm specialized in coffee. The maximization of the linear programming model gave results similar to reported resource use. The net income for the programmed model was ₡16,876. The increase over the reported income of ₡15,520 was explained by small savings in the accounting of harvesting costs and the fact that some of the reported expenditures were long-term investments.

In the model, permanent labor was fully employed during the harvest period from November through February. All 10 manzanas of land were used and family coffee harvesting was limited by the availability of family labor in December. An excess in the operating capital and credit row occurred in the model because the reported annual expenditures included some long-term investments.

The farm produced 190 fanegas of coffee using the highest yielding coffee activity permitted in the model.

Farm 6

The sixth farm studied was a small coffee farm with an absentee owner. The farm model allowed coffee yields slightly above those

reported by the farm. This reduced the net loss to ¢760. This loss occurred with an increase in both yield and coffee acreage above the reported numbers.

In the model, all four manzanas of land were planted to coffee for profit maximization. This occurred with 0.25 manzanas of new coffee planted.

The optimal solution maximized returns to land. Credit and operating capital were not limiting in the model, since reported preharvest expenditures were ¢4,000 compared to a ¢2,565 optimal preharvest expenditure. A large surplus of permanent labor occurred in all months except during the coffee harvest period.

The new coffee planting was not stable in the face of interest changes on the required investment. The rate initially used was 6 percent representing a minimum charge which government banks have used in a policy to subsidize agricultural investment. The new coffee was not planted if interest charges rose 0.8 percent. Beans and sesame were planted instead of coffee. The farm loss increased from ¢760 to ¢780.

Farm 7

The results of programming the seventh farm more than doubled reported net farm income from ¢3,345 to ¢7,147. In the optimal solution, coffee production was expanded with 0.26 manzanas planted to new coffee. Other production activities included were sun-cured tobacco, corn and beans. Optimal output, before parametric changes, was maximized with the production of 62.0 fanegas of coffee, 19 quintales of tobacco, 72.8 quintales of corn, and 18.9 quintales of beans.

The optimal production exhausted the credit and operating capital row, land rows from September through January, and the sun-cured tobacco contract. Permanent labor was exhausted in all months except July. Temporary labor was hired in all months except July and August. Labor supervision did not limit hiring temporary labor in any month.

The newly planted coffee was not stable when interest charges on investments were increased. Interest charges would block new plantings when the rate was increased 0.1 percent.

Farm 8

The eighth farm model results optimized resource use with the production of 19 fanegas of coffee, 7.8 quintales of sun-cured tobacco, 24.0 quintales of corn, 5.4 quintales of beans, and 6.5 quintales of sesame. Optimal net returns were ₡4,005 compared with a reported income of ₡2,653. Coffee acreage in the optimum program was the same as the farmer's reported acreage.

Credit was severely restricted on this small farm. The shadow price indicated that an additional colon of credit or operating capital could return ₡2.96 additional net income.

Land was fully utilized except in the month of February. Extra labor was available in all months except during the coffee harvest season. No temporary labor was hired. The restriction that allowed 0.5 manzanas of sun-cured tobacco was not used up.

Farm 9

The ninth farm produced coffee with modern inputs. The model included activities for horticultural crop production. The farm maximized income with coffee monoculture which yielded ₡86,761 net returns. The farmer's estimate of net returns was ₡90,000. Expendi-

tures for temporary labor were underestimated which limited the operating capital and credit row. The monthly labor supplies were fully used in January, February, June, July, September, November and December. Temporary labor was hired in June, July and September. Supervision limitations did not restrict temporary labor hiring.

Farm 10

Analysis of the tenth farm showed that an increase in farm income could accompany crop diversification. Net returns were increased from ₡17,160 to ₡29,489 when optimal use of other crops replaced coffee. However, this farm was reportedly upgrading coffee technology in order to receive ₡30,000 expected net returns with coffee monoculture. The optimal cropping pattern included five different crop-growing activities producing 213.3 fanegas of coffee, 48.0 tons of tomatoes, 148.0 tons of sugarcane, 708.0 quintales of sweetpotatoes and 3.14 quintales of chickpeas. Coffee trees were removed from 4.3 manzanas of land. The permanent labor supply was used up in January, February, April, August, September, November and December. Temporary workers were hired in January, February, September and December. The operating capital and credit constraint was limiting in the model. Supervisory capacity did not limit hiring temporary workers.

Farm 11

On the eleventh farm, programmed optimal solutions did not change coffee acreage from the reported land use. Other crops replaced pineapples. The reported net returns of ₡42,980 exceeded the optimal income of ₡24,536 of the model. This difference occurred because the model contained fruit prices for industrial use while the farmer produced 5.5 manzanas of pineapple for the fresh fruit market in

San José. The high domestic market prices of fruits and vegetables were not used in the model, since these prices could not be received if any significant portion of coffee resources were shifted into horticultural production.

Sales to maximize net revenue included 100.0 fanegas of coffee, 2.0 quintales of beans, 710.9 quintales of limes, 13.0 tons of tomatoes, 0.8 tons of green peppers, 236.0 tons of sugarcane and 254.5 quintales of sweetpotatoes. Land was fully utilized from November through April. Permanent labor was fully utilized in all months except October. Temporary labor was hired in January, February, April, June, August, September and December. The capacity to supervise labor was not an effective restriction in any month; however, slack supervisory capacity was reduced to 29.4 hours in January. The operating capital and credit row limitation was exhausted. Rotational limitations were not restrictive.

Farm 12

The twelfth farm was programmed with only the poorer coffee-producing activities of the Alajuela region. The farm reported poor coffee yields averaging 10 fanegas per manzana. The programmed optimal solution contained the traditional coffee activity which yielded nine fanegas per manzana. The activity based on the reported resource use was dominated by another coffee-producing activity. Net returns were maximized with the production of coffee, corn and beans and limes which netted ₡7,078 in the model. These returns were higher than the ₡6,122 calculated from the farmer report. Farm output included 22.5 fanegas of coffee, 24.1 quintales of corn, 4.8 quintales of beans and 717.2 quintales of limes.

Excess permanent labor occurred in all months except the coffee harvest period. No temporary labor was hired. All coffee was harvested with family labor. Credit was severely restricted.

Farm 13

The thirteenth farm was programmed using two different sets of fruit prices representing industrial prices with and without a processing plant located in the Acosta region. Two completely different diversification pictures are presented since it is questionable whether or not the area could support a processing plant. First, higher fruit prices were used to evaluate diversification alternatives. Limes were priced at ¢13.00 per quintal, blackberries at ¢1.00 per pound and oranges at ¢4.00 per hundred. The results of profit maximization in the model showed a sizable departure from the reported resource use. This does not dispute a theory of farmer profit motivation since completely different horticultural alternatives were placed in the model. Nevertheless, the model shows that if fruit prices were moderately high and stable, considerable changes would occur and coffee output would be reduced on farm 13.

Profits in the model were maximized with ¢89,948 netted from mixed coffee and lime production. Coffee tree destruction was programmed for 32.94 manzanas. Credit was limited, causing both semi-abandoned methods and traditional low-yield methods of coffee to be used in coffee production. Permanent labor was fully utilized in January, February, May, July, August, September, October, November and December. Temporary labor was hired in January, February, May, July, August and September. The limit on supervision for temporary workers was not effective.

Farm production was comprised of 195.6 fanegas of coffee and 17,780 quintales of limes. This coffee output was reduced from the present output of 900 fanegas. However, without favorable fruit prices, the maximum income for farm 13 was ₡67,694. Therefore, the reported income of ₡66,878 closely approximated the maximum of the model when only traditional crops were grown and coffee output was 900 fanegas. Other sales included 333.5 quintales of corn and 126.5 quintales of beans. In the model, a higher-yielding corn and bean activity substituted for the corn and bean activity actually reported in use.

In the second analysis, low fruit prices were programmed at ₡9.00 per quintal of limes, ₡0.50 per pound of blackberries and ₡3.00 per hundred oranges. With the lower fruit prices, the available credit and operating capital row was not a limiting factor. All coffee land remained in coffee but no new coffee was planted. The most advanced technology permitted by the model was used to produce corn and beans. Permanent labor was exhausted in all months except April and June; however, temporary labor was hired only in January, March, July, August, September and October. All but 96 fanegas of coffee were harvested with contract labor.

Farm 14

As with the preceding farm, the fourteenth farm was programmed using high and low fruit prices. With the higher fruit prices, optimization of the model resulted in considerable departure from reported practices. Although no coffee trees were removed, output of coffee was reduced from 70.0 to 18.4 fanegas with coffee production activities using low-yield and semi-abandoned methods. Nine

manzanas of limes utilized the non-coffee land and 3,600 quintales of limes were produced. Net returns in the model were ₡24,222. The farm reported income was much lower with ₡11,446 netted from traditional grain crops and common coffee practices.

The operating capital and credit row were severely limited in the model with a marginal return of ₡1.51 per ₡1.00 of credit. Permanent labor was exhausted except in March and April. The model resulted in hired labor in January, February, May, June, July, August and September. Labor supervision was not a limiting factor.

The optimal solution in the model for farm 14 was completely different when lower fruit prices were used to represent alternatives without a nearby processing plant. The maximization of net returns with traditional crop alternatives resulted in 70.0 fanegas of coffee output. Maximum net returns in the model were higher than reported returns, ₡16,718 compared to ₡11,446. The increase was accomplished with higher returns to corn and beans which were programmed with moderately poor yields that greatly exceeded reported farm production. Nevertheless, insofar as coffee production was concerned, the model results coincided with the actual reported production.

Maximum net returns occurred with the production of 70.0 fanegas of coffee, 261.0 quintales of corn and 99.0 quintales of beans. Operating capital was limiting and the family labor supply was exhausted in all months except March, April and June. Labor was hired in May, August, September, October, November and December.

Farm 15

The fifteenth farm also was given two different fruit price situations. With high fruit prices used first to represent production

potentials given a processing plant in the region, the farm model maximized net returns at ₡5,459. In comparison, reported production netted only ₡1,403. Profits were maximized by shifting 0.26 manzanas of coffee into lime production. Farm output included 17.4 fanegas of coffee and 105.9 quintales of limes.

The farm model used all credit and operating capital available. Labor was fully used only from October through February during the coffee harvest. Land was fully utilized and no temporary labor was hired. Of the ₡5,459 netted on the farm, ₡2,353 were received from off-farm coffee harvesting.

When lower fruit prices were used in the linear programming analysis of farm 15, all land was planted to coffee. Farm production in the model slightly exceeded reported coffee output. Income was above that reported because the model included temporary outside income from coffee harvesting as part of farm income. Of the ₡5,209 net returns, ₡2,308 was income from coffee harvesting work on other farms. Commonly grown coffee replaced the reported poorer yielding coffee-orange activity.

Coffee production maximized the returns to land and harvest time labor. Credit was not a limiting resource when low fruit prices were used in the model. The family labor supply exceeded all monthly demands for labor and no labor was hired. The excess family labor was sold during the coffee harvest period and was unused the remainder of the year. Twenty fanegas of coffee were produced with the optimal use of resources.

Farm 16

The sixteenth farm was also programmed with high and low fruit

prices. The farm had reported 7.5 fanegas of coffee production from 1.5 manzanas of coffee. When high fruit prices were used, the maximization of profits shifted resources into lime production and coffee land was utilized in semi-abandoned coffee production. Net returns reached ¢4,307 when maximized which surpassed the ¢1,339 calculated as expected income with reported resource use. However, ¢2,273 out of the ¢4,307 represented harvest labor sales.

Credit was severely restricted when high fruit prices reflected a strong local market. Over ¢5.30 marginal returns were estimated per colon of additional credit. Almost 1.2 manzanas of land were idle in the optimal solution. Output included 3.0 fanegas of coffee, 382.4 quintales of limes, 18.2 quintales of corn and 27.3 quintales of beans. Permanent labor was fully employed only during the coffee harvest and no temporary workers were hired.

When low fruit prices were used in the programming model, limes were excluded and resources were allocated to traditionally grown coffee and low-yielding corn and bean activities. Credit was severely restricted with a marginal return for operating expenditures estimated at ¢3.22 per ¢1.00. Profits were maximized with 0.77 manzana of land idle. Excess permanent labor occurred in all months except during the coffee harvest. No temporary workers were hired. Optimal sales included 9.0 fanegas of coffee, 54.0 quintales of corn and 32.2 quintales of beans. Income was maximized at ¢3,612, of which ¢2,145 came from labor selling for coffee harvest.

Policy Analysis

Education for Better Farm Management

The first section of this chapter compared reported and optimal

programmed resource use given the price and credit relationships faced by the farmers without a positive policy to foster crop diversification. Nevertheless, the changes in resource use may be attributed to a general policy of better farmer education and expanded extension work that would be required before part of the alternatives programmed could be put into practice.

Therefore, the first policy consideration to be considered represents education for better farm management. It is often heard that farmers produce coffee because of non-economic motivations, that they are reluctant to change, or that they maintain traditional cropping patterns out of ignorance. Table 2 shows comparisons between the reported and optimal values for net returns and for coffee outputs. The results do not indicate that irrational overproduction of coffee was prevalent. Of the 16 farms studied, only two farms demonstrated overproduction of coffee. Overproduction on farm 3 could be attributed to overintensification where returns could be increased by reducing inputs and yields. The huge quantities of fertilizer reported represented either mismanagement or hidden investment.¹ Overproduction on farm 10 occurred because either sugarcane or horticulture gave returns high enough to replace part of the moderately high-yielding coffee. The lower programmed coffee output on these two farms was countered by higher output on other farms.

While the sample is too small to support broad generalizations, some overproduction of coffee beyond that quantity dictated by strict

¹Hidden investment in this case may arise when increased annual expenditures occur for a short period before yields are increased to full potential.

Table 2. Comparisons between reported and optimal incomes and coffee output

Farm ^a	Net returns		Coffee output	
	Reported (colones)	Optimal (colones)	Reported (fanegas)	Optimal (fanegas)
1	22,500	19,781	82.8	82.8
2	15,250	18,025	179.9	193.2
3	34,130	35,543	1,000.0	750.0
4	14,700	31,667	80.0	225.0
5	15,520	16,877	190.0	190.0
6	- 6,760	- 760	56.3	76.0
7	3,345	7,147	45.0	62.0
8	2,653	4,005	15.0	19.0
9	90,000	86,761	1,000.0	997.2
10	17,160	29,489	300.0	213.3
11	42,980	24,536	100.0	100.0
12	6,122	7,078	25.0	22.5
13A	66,878	89,948	900.0	195.6
13B	66,878	67,694	900.0	900.0
14A	11,446	24,222	70.0	18.4
14B	11,446	16,718	70.0	70.0
15A	1,403	5,459	10.0	17.4
15B	1,403	5,209	10.0	20.0
16A	1,339	4,307	7.5	3.0
16B	1,339	3,612	7.5	9.0

^aThe letters A and B are used to designate different fruit pricing used in Acosta. A's are used to indicate the situations using high fruit prices and B's are used to indicate the situations using low fruit prices.

profit maximization is indicated. Most of the potential for income improvement occurred with the land not planted to coffee. Labor selling activities for the coffee harvest made sizable contributions to the higher optimal incomes of the smaller farms.

Of the 20 farm situations studied, three reported higher incomes than the optimal permitted in the model. In farm 1 and farm 9 this difference was due to a lower wage cost estimation in the farmer report than was permitted in the model. More significantly, the reduced optimal income on farm 11 came about because the model only allowed pineapple sales for export or industrial use while the farm produced for a much higher domestic fresh-fruit market.

Markedly increased incomes were accompanied by reductions in coffee output only when high return fruit or vegetable crops were considered as alternatives. Thus the higher incomes are associated with higher risks. Optimal allocation of resources reduced coffee output 3.06 percent on the eight farms of the Palmares-San Ramón area, and 6.46 percent on the four farms of the Alajuela area. For Acosta, optimal resource allocation increased coffee output 1.16 percent when low fruit prices were used but decreased coffee output 76.26 percent when high fruit prices were used. A sizable reduction occurred in the Acosta output only when high yielding alternatives were compared with low yielding coffee.

Changes which reduced coffee output brought activities into production which utilized more modern inputs than the alternative crops usually receive in Costa Rica. This gives rise to a question of whether or not the same relationships would exist if new coffee growing activities represented higher levels of technology in coffee

production. In order to keep the model representative of current technological proficiency, certain high-yielding coffee activities were flagged from use in 17 of the 20 farm situations. Then parametric programming was used to increase coffee transfers until reported yields of the better farms were equaled. The results showed that on some farms modernization would be justified if over 60 percent of anticipated yields were obtainable. In the Alajuela and Palmares-San Ramón areas, it would pay most farms to adopt modern inputs if over 80 percent of the recorded yields were obtainable. In Alajuela technological change permitted yield increases from 20 to 25 fanegas per manzana. In Palmares-San Ramón the yields were increased from 19 to 27.6 fanegas per manzana. Yields were increased from 10 to 14 fanegas per manzana in Acosta.

The results of the programmed technological advances are given in Table 3. In the Alajuela and Palmares-San Ramón farm situations, optimal coffee output was increased 72.4 percent and farm income was increased 110.23 percent when higher-yielding coffee activities modified the output of nine farms. In the Acosta programs, coffee output was increased 198.81 percent and net income was increased 9.38 percent when technological changes for coffee were permitted in the four farm situations when high fruit prices were used. Given low fruit prices, coffee output only increased 15.98 percent but income increased 26.98 percent in the Acosta farm situations.

Higher levels of technology brought small increases in coffee acreage on a number of the farms. The planting of new coffee was limited by credit restrictions. The gains in programmed income were sufficiently high to motivate change if the improved technology can

Table 3. The effects of improving coffee production technology on coffee production and income

Farm ^a	Coffee output		Incomes	
	Current technology	Improved technology	Current technology	Improved technology
	(fanegas)	(fanegas)	(colones)	(colones)
3	750.0	1,462.8	35,543	138,168
4	225.0	425.0	31,667	62,013
5	190.0	276.0	16,877	29,739
6	76.0	110.4	- 760	4,583
7	62.1	94.3	7,147	10,979
8	19.0	27.6	4,005	5,720
10	213.3	281.4	29,489	38,460
11	100.0	120.0	24,536	27,989
12	22.5	60.1	7,078	9,440
13A	195.6	656.0	89,948	101,272
13B	900.0	1,032.1	67,694	90,709
14A	18.4	18.4	24,222	24,274
14B	70.0	94.5	16,718	18,361
15A	17.4	23.0	5,459	5,707
15B	20.0	23.0	5,209	5,707
16A	3.0	3.0	4,307	4,307
16B	9.0	9.0	3,612	3,612

^aThe letters A and B are used to designate different fruit pricing used in Acosta. A's are used to indicate the situations using high fruit prices and B's are used to indicate the situations using low fruit prices.

increase production to the levels reported on the better farms. The higher yields obtainable in Alajuela and Acosta resulted in greater increases in income in comparison with the Acosta farms. Coffee production, therefore, is expected to increase unless positive aids to diversification or production controls are put into effect.

Comparisons between optimal coffee production and maximum net returns for traditional versus new enterprises are shown in Table 4. On the Alajuela farms, returns from sugarcane approached those of horticultural crops and optimal coffee output was not reduced when the new crops were included among the alternatives. However, incomes were increased where coffee yields were limited to 20 fanegas per manzana. Actually, the higher credit requirements of the horticultural alternatives caused the optimal coffee tree destruction to be lower when horticultural crops were included on Farm 10.

In the Acosta farm situations the exclusion of fruit production alternatives lowered optimal income and caused a sizable increase in coffee output. Farm 13 and farm 14 had sufficient capital and credit to respond to fruit production opportunities with sizable increases in income. The additional income potential of fruits and vegetables was limited on the smaller farms by a shortage of operating capital and credit.

Taxation or Price Reduction

The stability of coffee production in farm management plans was further examined with price declines parametrically programmed into each farm situation. Table 5 shows the effect of price declines on coffee output. Reduced output with \$5.00 per fanega price declines was limited to the blocking of new plantings of coffee trees and the

Table 4. Comparisons of optimal incomes and coffee outputs with traditional versus new enterprises on farms in Alajuela and Acosta

Farm	Coffee output		Net income	
	Traditional enterprises (fanegas)	New enterprises (fanegas)	Traditional enterprises (colones)	New enterprises (colones)
9	997.2	997.2	86,761	86,761
10	163.8	213.3	22,586	29,489
11	100.0	100.0	22,239	24,536
12	22.5	22.5	7,003	7,078
13	900.0	196.5	67,694	89,948
14	70.0	18.4	16,718	24,222
15	20.0	17.4	5,209	5,459
16	9.0	3.0	3,612	4,307

Table 5. Optimal coffee production with specified price declines per fanega of coffee

Farm	At base price	Reduction in price					
		£5	£10	£20	£30	£40	£50
		fanegas					
		£75					
1	82.8	82.8	82.8	82.8	82.8	82.8	82.8
2	193.2	193.2	193.2	193.2	193.2	193.2	193.2
3	750.0	750.0	750.0	750.0	669.2	663.8	663.8
4	225.0	225.0	225.0	222.1	192.0	192.0	156.6
5	190.0	190.0	190.0	190.0	190.0	190.0	190.0
6	76.0	71.3	71.3	71.3	71.3	71.3	71.3
7	62.0	57.0	57.0	57.0	57.0	57.0	57.0
8	19.0	19.0	19.0	17.5	17.5	17.5	17.5
9	997.2	997.2	997.2	997.2	997.2	997.2	821.0
10	213.3	213.3	213.3	213.3	187.2	142.0	72.0
11	100.0	100.0	100.0	100.0	100.0	100.0	79.4
12	22.5	22.5	22.5	22.5	22.5	22.5	22.5
13A	195.6	195.6	195.6	133.2	133.2	107.9	107.9
13B	900.0	900.0	900.0	814.0	814.0	594.2	344.0
14A	18.4	18.4	18.4	13.6	13.6	13.6	13.6
14B	70.0	69.8	66.5	61.1	60.1	60.1	60.1
15A	17.4	17.4	17.4	8.2	8.2	8.2	8.2
15B	20.0	20.0	20.0	20.0	20.0	20.0	20.0
16A	3.0	3.0	3.0	3.0	3.0	3.0	3.0
16B	9.0	9.0	9.0	9.0	9.0	4.7	4.7

substitution of corn and beans for low-yielding coffee on farm 14. Taxes up to \$10.00 per fanega would have little effect on coffee output of the farms programmed. Except for the newly planted coffee, coffee production was not responsive to price declines up to ₡20.00 per fanega. High-yielding coffee and semi-abandoned coffee were the most stable. With high coffee yields, the alternatives are poorly competitive and with very low-yields, stability is assured by severe credit limitations. Resources were shifted away from coffee when the coffee price fell to new market price levels.

Table 6 shows the effect of price declines on coffee acreage. Coffee acreage was more stable than coffee output. Coffee land was notably more stable on the smaller farms as price declines were programmed.

The effect of price declines on farm incomes is shown in Table 7. Price declines reduced income more rapidly than output and had the strongest effect on those farms highly specialized in coffee production. For example, given a ₡40 per fanega price decline, income fell 54 percent on the three largest coffee producing farms and only 22 percent on the farms with optimal production less than 100 ganegas. Net returns on farm 2, farm 5, farm 9 and farm 13B, all of which specialized in coffee production, were reduced over 50 percent by a ₡50 per fanega price decline. Of those farms specializing in coffee production, only on farm 10 did diversification possibilities hold income above 50 percent of initial levels when price was reduced 25 percent. In the Acosta farm situations, high fruit prices resulted in both higher incomes and greater income stability in the face of coffee price declines. The effect of a price decline on income was

greater on the farms from the Palmares-San Ramón area where expandable alternatives fell further behind coffee in terms of net returns.

The alternative crops that increased first as coffee prices were programmed downward are shown in Table 8. In the Palmares-San Ramón area the farms first responding to a price decline were those with unused tobacco allotment. Among the Alajuela farms studied the larger farms responded first to a price decline. This also held true among the farms from Acosta although irregularities occurred with respect to which set of fruit prices were used.

Payments for Coffee Removal

The programmed effect upon coffee output of annual payments for coffee tree removal is shown in Table 9. Farm 1, farm 2 and farm 9 were not responsive to removal subsidies because of high returns to coffee. Farm 16 was not responsive because of severe credit limitations.

Annual payments equal to 20 percent of gross coffee earnings per manzana were effective in changing optimal resource allocation in five of the 20 farm situations studied. Given a 25 percent discounted price for 25 percent of the output of coffee, the payment of 20 percent of base gross returns could be made for the withdrawal of coffee production without extra taxes or loss to coffee producers. The following formula can be used for calculating a self-paying subsidy for coffee removal. Let the coffee price be unchanged as coffee in excess of the quota is taken out of production.

Then:

$$\frac{PT + (P - DP)N}{T + N} = \frac{PT}{T + SN}$$

Table 8. Alternative crops increased first by declines in coffee prices

Farm	Price reduction per fanega (colones)	Crop increased
1	100	None
2	91	Beans, sesame
3	40	Beans, corn
4	15	Tobacco, beans
5	57	Beans, sesame
6	58	Beans, sesame
7	90	Castorbeans, milk
8	15	Tobacco
9	21	Sugarcane, beans
10	22	Tomatoes, sugarcane
11	43	Limes, peppers
12	60	Limes
13A	14	Limes
13B	14	Corn, beans
14A	25	Limes
14B	55	Corn, beans
15A	29	Limes
15B	58	Corn, beans
16A	100	None
16B	32	Corn, beans

Table 9. Coffee production with annual payments for coffee removal

Farm	No payments	Continuing payments made at the end of each season				
		£400	£600	£800	£1,000	£1,200
		----- fanegas -----				
1	82.8	82.8	82.8	82.8	82.8	82.8
2	193.2	193.2	193.2	193.2	193.2	193.2
3	750.0	750.0	669.2	462.8	261.2	208.7
4	225.0	225.0	225.0	221.4	192.0	168.8
5	190.0	190.0	190.0	190.0	190.0	166.5
6	71.3	71.3	71.3	71.3	71.3	5.0
7	57.0	57.0	57.0	57.0	57.0	57.0
8	19.0	19.0	19.0	19.0	19.0	19.0
9	997.2	997.2	997.2	997.2	997.2	997.2
10	213.3	213.3	187.2	142.0	72.0	67.8
11	100.0	100.0	100.0	100.0	79.4	13.9
12	22.5	22.5	22.5	22.5	22.5	22.5
13A	195.6	133.2	133.2	128.9	128.9	106.8
13B	900.0	814.0	594.2	453.7	344.1	300.8
14A	18.4	18.4	18.4	13.6	13.4	12.2
14B	70.0	70.0	70.0	70.0	62.5	45.3
15A	17.4	17.4	17.4	8.2	8.2	8.2
15B	20.0	20.0	16.8	16.8	16.8	16.8
16A	3.0	3.0	3.0	3.0	3.0	3.0
16B	9.0	9.0	9.0	9.0	9.0	9.0

^aNew plantings were blocked.

and

$$S = \frac{TD}{T + N - ND}$$

where:

P = price in traditional market,

D = discount for sale in new market,

T = traditional market quota,

N = surplus over quota,

S = share of payment for exiting firms.

This indicated that coffee could be removed from farm 3, farm 4, farm 10, farm 13A and 13B with a scheme to pay for coffee removal out of total sales revenue without lowering the average price to producers. However, such a scheme would reduce coffee output over 10 percent only on farm 3, farm 10 and farm 13A. A shortage of operating capital blocked coffee removal since available credit was reduced by the cost of coffee tree removal.

Annual payments, as shown in Table 10, either increased or did not affect farm income. One would expect such a program of self-financing allotment payments to be politically acceptable since it would not lower the income for any farm. However, the effect upon coffee production appears to be relatively low with respect to the quantities of coffee produced above traditional market quotas. Additional money could be made available from the Diversification Fund of the International Coffee Agreement but even with this extra subsidy the annual payments are unlikely to motivate much change. If \$0.30 per quintal of sales were made available for this subsidy, annual payments could be increased less than \$20 per fanega removed, assuming that payments were spread over 10 percent of the base production.

Table 10. Net farm income with annual payments for coffee removal

Farm	No payments ^a	Continuing payments made at the end of each season				
		£400	£600	£800	£1,000	£1,200
-----Colones-----						
1	19,781	19,781	19,781	19,781	19,781	19,781
2	18,025	18,025	18,025	18,025	18,025	18,025
3	35,543	35,543	35,835	37,136	42,735	49,395
4	31,667	31,667	31,675	31,727	31,829	32,329
5	16,887	16,887	16,887	16,887	16,887	17,002
6	- 780	- 780	- 780	- 780	- 780	- 607
7	7,145	7,145	7,145	7,145	7,145	7,145
8	4,005	4,005	4,005	4,055	4,005	4,005
9	86,761	86,761	86,761	86,761	86,761	86,761
10	29,489	31,222	32,245	33,537	35,692	37,989
11	24,536	24,536	24,536	24,536	24,583	25,253
12	7,078	7,078	7,078	7,078	7,078	7,078
13A	89,948	103,169	110,228	117,357	124,537	131,717
13B	67,694	69,611	71,683	77,482	84,880	93,765
14A	24,222	24,222	24,222	24,257	24,302	24,363
14B	16,718	16,718	16,718	16,718	16,805	17,069
15A	5,459	5,656	5,618	5,704	5,831	5,958
15B	5,209	5,209	5,215	5,279	5,344	5,409
16A	4,307	4,307	4,307	4,307	4,307	4,307
16B	3,612	3,612	3,612	3,612	3,612	3,612

^aNew plantings are blocked.

This could increase total payments to approximately ₡60 per fanega. Therefore, before annual payments may effectively remove coffee, the alternative use of resources must give returns competitive with coffee and ample credit must be available to finance such alternative activities.

Payment for coffee removal could be more efficacious if made in a lump sum provided that the marginal interest rate facing the farmer is well above the rate at which money is available from bank sources. A lump sum payment equal to the earning differential between coffee and its next best alternative divided by the marginal interest rate for the farmer would be necessary to motivate rational change. Poorer farmers with scarce capital and poor credit standings would be most responsive to such payments if they were given the knowledge required to change traditional cropping patterns.

The value of a lump sum payment is shown in the following example. Assume that the government can borrow money at 10 percent annually for a 10-year period and that a farmer's marginal interest earning rate is 30 percent. Then the cost of generating a perpetual psychic income flow of ₡100 per year is ₡50 for each of 10 years. Higher farmer interest rates or extended pay-off periods would further reduce the annual cost of generating a given psychic income flow.

Because of the difference between bank rates and marginal interest rates for near subsistence farmers, lump sum allotment payments would cheapen the payments required to motivate change. Installment payments computed as a share payment for destroyed coffee could be paid to a government fund out of coffee export sales without lowering the average price paid to remaining producers. The government fund then

could borrow to pay lump sum allotments for coffee removal. If the above example of 30 percent farmer marginal interest holds true, then the cost of generating an income flow is halved and changes in output can be motivated through a program of allotment payments in 10-year installments from coffee sales without lowering average price. Limitations of credit affecting the outputs and incomes would be removed as the subsidy payments would be a source of operating capital.

The cropping pattern encouraged by subsidy payments for coffee removal is similar to the changed output programmed with coffee price declines. Favored crops are listed in Table 11.

Price Differentiation

Price differentiation is theoretically efficient in that it permits the national marginal returns for coffee to be passed back to the farmer. Output of coffee should be reduced or held constant while income is either increased or unchanged. One difficulty in applying this measure is the establishment of the quota for the traditional, higher-priced market. If optimal coffee production is above the historical base used to calculate the traditional market quota, coffee price averages will tend to be lowered. If optimal coffee production falls below historical production, the price averages will tend to be increased. If new crops shift resources away from coffee in the initial optimal solution, higher marginal returns to coffee may cause an increase in coffee production as some resources are shifted back into coffee production.

Table 12 shows optimal incomes and coffee outputs with single and differentiated coffee prices. Of those farms with increased incomes, coffee output was unchanged on five farms, increased on two farms,

Table 11. The alternative crops increased first by annual payments for coffee removal

Farm	Annual payment	Crop increased
	per manzana (colones)	
1	3,000 ^a	None
2	2,900	Mixed crops
3	600	Corn, beans
4	600	Corn, beans
5	1,100	Beans, sesame
6	1,100	Corn, beans, sesame
7	2,200	Corn, beans, castorbeans
8	2,600	Corn, beans, sesame
9	1,700	Sugarcane
10	500	Sugarcane
11	900	Limes
12	3,000	None
13A	400	Limes
13B	200	Corn, beans
14A	700	Limes
14B	900	Corn, beans ^b
15A	800	Limes
15B	600	Corn, beans
16A	3,000	None
16B	3,000	None ^b

^aWhen changes were not initiated by the levels of payment first programmed, additional runs extended the levels of payment.

^bLand was idled as credit became more limited due to coffee removal.

Table 12. Comparisons of income and coffee production for differentiated prices versus single prices

Farm	Incomes		Coffee	
	Single price (colones)	Two prices (colones)	Single price (fanegas)	Two prices (fanegas)
1	19,781	19,781	82.8	82.8
2	18,025	17,484	193.2	193.2
3	35,543	45,709	750.0	750.0
4	31,667	26,220	225.0	192.0
5	16,877	16,877	190.0	190.0
6	- 760	- 1,389	76.0	71.3
7	7,147	6,657	62.0	57.0
8	4,005	3,880	19.0	17.5
9	86,761	86,870	997.2	997.2
10	29,489	32,330	213.3	225.0
11	24,536	24,536	100.0	100.0
12	7,078	7,176	22.5	22.5
13A	89,948	96,670	195.6	650.0
13B	67,694	70,792	900.0	650.0
14A	24,222	24,448	18.4	18.4
14B	16,718	17,056	70.0	60.1
15A	5,459	5,975	17.4	8.2
15B	5,209	4,922	20.0	20.0
16A	4,307	4,350	3.0	3.0
16B	3,612	3,586	9.0	5.6

and reduced on three farms. Of the eight farms with reduced coffee output, five had income reduced below the single price optimum.

When differentiated coffee prices were used to separate sales into new and traditional markets, optimal output was reduced or unchanged on farms where the base used for establishing the traditional market quota was equal to or less than the initial optimal coffee output. However, in those cases where new activities replaced coffee and optimal output fell well below the historical base, then the optimal coffee output increased or was unchanged when prices were differentiated. Income increases were associated with above optimal production in the base period. Increased shifts toward lime or vegetable production did not occur when prices were differentiated to reflect different export earnings in new markets and traditional markets.

Reduction of Credit

The reduction of credit has been suggested as an effective means of controlling coffee output. As Table 13 shows, coffee output is reducible if this measure can be imposed. However, there are effects on farm incomes also (Table 14). In 10 of the 20 farm situations, income was first reduced by credit restrictions without affecting coffee production. In four situations where horticultural crops replaced coffee in the initial solution a reduction in operating credit actually brought increased coffee production within certain levels of constraint. The magnitude of the income reduction is greater where the optimal solution contained alternative crops. Since credit availability was tied to coffee land in the model, a credit restriction cut coffee production without encouraging diversification. Coffee land

Table 13. Optimal coffee production with various levels of reduced credit

Farm	Base credit and capital	Credit reductions expressed as a percentage of base credit and capital						
		10%	20%	30%	40%	50%	60%	70%
----- fanegas -----								
1	82.8	82.8	82.8	82.8	82.8	82.8	82.8	79.1
2	193.2	193.2	174.5	153.6	132.7	111.7	90.8	
3	750.0	750.0	750.0	750.0	720.3	620.0	547.2	
4	225.0	219.6	207.1	192.0	188.3	174.7	162.4	
5	190.0	190.0	174.9	159.1	143.4	127.6	110.8	
6	76.0	76.0	76.0	74.5	71.3	62.9	53.1	
7	62.0	57.0	57.0	57.0	57.0	53.4	48.9	
8	19.0	19.0	19.0	17.1	14.9	12.7	10.5	
9	997.2	935.0	870.7	802.0	733.4	644.8	591.2	
10	213.3	213.3	220.5	244.8	258.3	274.0	277.5	
11	100.0	100.0	99.9	92.1	83.5	75.7	80.5	
12	22.5	22.5	22.5	22.5	22.5	22.5	20.1	
13A	195.6	204.3	242.2	235.4	246.7	285.2	323.8	
13B	900.0	868.0	718.7	647.5	576.4	491.6	406.8	
14A	18.4	14.0	14.0	16.4	23.8	27.4	27.8	
14B	70.0	63.1	52.9	52.9	52.1	54.6	48.8	
15A	17.4	18.5	18.9	17.3	15.6	14.0	12.3	
15B	20.0	20.0	18.9	17.3	15.6	14.0	12.3	
16A	3.0	3.0	3.0	3.0	3.0	3.0	3.0	
16B	9.0	9.0	9.0	8.9	6.3	3.7	3.0	

Table 14. Optimal net income with various levels of reduced credit

Farm	Base credit and capital	Credit reductions expressed as a percentage of base credit and capital						
		10%	20%	30%	40%	50%	60%	70%
-----colonies-----								
1	19,781	19,550	18,552	17,215	15,846	14,477	13,108	10,680
2	18,025	18,025	18,025	15,487	12,643	9,799	6,956	3,987
3	35,543	35,543	35,543	35,543	33,945	28,527	20,041	10,964
4	31,667	30,484	29,075	27,511	25,769	23,916	22,026	19,935
5	16,877	16,877	16,877	15,178	13,412	11,646	9,879	7,938
6	- 760	- 760	- 760	- 760	- 767	- 797	- 1,804	- 2,909
7	7,147	6,985	6,810	6,611	6,198	5,407	4,189	2,894
8	4,005	3,738	3,471	3,204	2,908	2,606	2,304	2,003
9	86,761	79,917	72,724	64,804	56,883	48,963	40,288	26,877
10	29,489	28,264	26,790	25,252	23,644	21,381	18,742	15,106
11	24,546	23,903	23,246	22,414	21,305	19,238	15,886	12,235
12	7,078	6,597	6,116	5,635	5,154	4,672	4,191	3,561
13A	89,948	83,719	76,810	69,461	61,948	54,280	46,378	38,475
13B	67,694	65,277	59,563	53,725	47,741	41,359	34,501	27,640
14A	24,222	23,222	21,826	20,288	18,608	16,779	14,797	12,671
14B	16,718	15,980	15,157	14,322	13,362	12,165	10,797	9,426
15A	5,459	5,353	5,247	5,090	4,904	4,718	4,533	4,347
15B	5,209	5,209	5,209	5,090	4,904	4,718	4,533	4,347
16A	4,307	3,949	3,591	3,233	2,875	2,517	2,159	1,757
16B	3,612	3,394	3,177	2,959	2,738	2,440	2,141	1,757

use was reduced only when new plantings occurred in the model. Semi-abandonment of coffee did not use up restricted credit and the stability of land use is shown in Table 15.

The shadow prices of the credit row are given in Table 16. These showed very high returns to additional credit especially as credit reductions occurred. Before short-term credit effectively reduced coffee production, the marginal returns greatly exceeded the usurious rates of money lenders.

Movement of Labor

The possibility that a higher demand for off-farm labor could shift resources out of coffee production was considered. Table 17 shows a movement of family workers in 11 of 17 farm situations having family labor. However, coffee output was not changed in 15 of the 17 cases. On farm 10, moving workers would increase optimal coffee production and on farm 13B, the movement brought about a slight decrease in programmed coffee output. Higher family income from new jobs indicated that family workers received less than legal wage rates.

A similar inquiry also indicated that more permanent labor was hired than needed for maximum net returns. The relaxation of labor inflexibility showed that 12 of 20 farms could increase profits by encouraging employee mobility to other jobs. As shown in Table 18, coffee production was influenced on only two of 17 farms.

The movement of labor altered farm output on some farms but the effects upon coffee output was negligible. Of the farms studied, the smaller farms have larger percentages of excess labor. This may be necessary to assure ample harvesting labor on a number of the farms although motivations other than profit maximization appear to be manifested.

Table 16. Marginal returns to credit with various levels of reduced credit

Farm	Base credit and capital	Credit reduction expressed as a percentage of base credit and capital						
		10%	20%	30%	40%	50%	60%	70%
-----manzanas-----								
1	0.0	0.94	2.97	3.11	3.11	3.11	3.11	8.37
2	0.0	0.0	0.0	7.11	7.11	7.11	7.11	8.37
3	0.0	0.0	0.0	0.0	0.60	1.12	1.25	1.35
4	0.57	0.81	0.84	0.93	1.08	1.11	1.12	1.42
5	0.0	0.0	0.0	2.76	2.76	2.76	2.76	3.21
6	0.0	0.0	0.0	0.0	0.04	1.22	2.76	2.76
7	0.37	0.39	0.44	0.54	1.37	2.18	2.99	3.24
8	2.96	2.96	2.96	2.96	3.35	3.35	3.35	3.35
9	3.08	3.08	3.57	3.57	3.57	3.57	4.66	6.13
10	0.76	0.91	0.98	0.98	1.05	1.49	2.31	2.31
11	0.67	0.73	0.90	1.25	1.26	3.71	3.87	4.36
12	4.31	4.31	4.31	4.31	4.31	4.31	4.31	7.35
13A	1.19	1.27	1.38	1.46	1.54	1.54	1.54	1.54
13B	0.0	1.10	1.13	1.13	1.21	1.33	1.33	1.34
14A	1.51	1.96	2.59	2.59	3.08	3.08	3.58	3.58
14B	0.0	1.32	1.40	1.40	1.63	2.28	2.30	2.31
15A	1.28	1.28	1.28	2.25	2.25	2.25	2.25	2.25
15B	0.0	0.0	0.0	2.25	2.25	2.25	2.25	2.25
16A	5.31	5.31	5.31	5.31	5.31	5.31	5.31	6.22
16B	3.22	3.22	3.22	4.42	4.42	4.42	4.42	6.22

Table 17. Optimal family income with and without off-farm employment opportunities

Farm	No off-farm employment		Off-farm employment			Change in coffee output (percent)
	Workers (number)	Income (colones)	Workers (number)	Total income (colones)	Farm income (colones)	
1	1.0	19,781	0.0	21,426	18,310	0.0
2	2.0	18,025	0.0	21,353	15,121	0.0
3	0.0	35,543	0.0	35,543	35,543	0.0
4	3.0	31,667	0.0	34,023	24,675	0.0
5	2.0	16,877	0.0	20,538	14,306	0.0
6	0.0	-	0.0	-	760	0.0
7	1.0	7,147	1.0	7,147	7,147	0.0
8	0.0	4,005	0.0	6,551	3,435	0.0
9	2.0	86,761	2.0	86,761	86,761	0.0
10	2.0	29,489	0.0	31,729	25,497	9.06
11	1.0	24,536	1.0 ^a	24,537	24,518	0.0
12	3.0	7,078	0.0	14,716	5,368	0.0
13A	4.0	89,948	4.0	89,948	89,948	0.0
13B	4.0	67,964	1.2	70,572	61,847	-0.44
14A	3.0	24,222	3.0	24,222	24,222	0.0
14B	3.0	16,718	3.0	16,718	16,718	0.0
15A	1.0	5,459	0.0	7,843	4,727	0.0
15B	1.0	5,209	0.0	7,593	4,477	0.0
16A	1.0	4,307	0.0	6,632	3,516	0.0
16B	1.0	3,612	0.0	5,803	2,678	0.0

^aFractional labor movement is lost in rounding.

Table 18. Optimal farm income and the reduction of permanent labor

Farm	Present labor		Reduced labor permitted		Change in coffee output (percent)
	Employees (number)	Farm income (colones)	Employees (number)	Farm income (colones)	
1	2.0	19,781	1.1	20,610	0.0
2	5.0	18,025	0.0	26,032	0.0
3	9.0	35,543	1.3	37,874	0.0
4	3.0	31,667	1.0	32,535	0.0
5	2.0	16,877	0.0	19,850	0.0
6	4.0	- 760	1.2	3,870	0.0
7	1.0	7,147	1.0	7,147	0.0
8	1.0	4,005	0.0	5,643	0.0
9	10.0	86,761	10.0	86,761	0.0
10	5.0	29,489	2.9	30,387	12.94
11	1.0	24,536	1.0	24,536	0.0
12	2.0	7,078	0.0	10,354	0.0
13A	9.0	89,948	9.0	89,948	0.0
13B	9.0	67,694	6.0	71,248	0.0
14A	0.0	24,222	0.0	24,222	- 1.09
14B	0.0	16,718	0.0	16,718	0.0
15A	0.0	5,459	0.0	5,459	0.0
15B	0.0	5,209	0.0	5,209	0.0
16A	1.0	4,307	0.0	5,036	0.0
16B	1.0	3,612	0.0	4,207	0.0

Extra Credit

Income and coffee output with special credit for crops other than coffee and expanded total credit are shown in Table 19. The poorer farms from Palmares shifted resources into coffee production and expanded coffee output with both special and extra credit. With the special credit, capital formerly used for corn and tobacco was released for coffee.

Programmed extra credit made an additional ₡2,000 per manzana available for annual expenditures. The major difference between the programmed effects of special credit and extra credit was that more money was made available in the latter. The incomes for those farm situations with horticultural crops considered among the diversification alternatives were increased over 10 percent on seven of the eight farms, over 50 percent on six of eight farms and over 100 percent on four of eight farms.

Increasing the availability of credit increased coffee production in two of the 20 farm situations studied, decreased production in seven cases and did not affect coffee production in seven cases. In the Palmares and San Ramón situations, programmed increased credit did not cause the alternatives to substitute for coffee. This was also true in the Acosta situations with low fruit prices. Increased credit effectively reduced coffee output in the farm models where fruit and vegetable crops offered a higher net return per manzana than coffee. Only on farm 11 did labor supervision restrictions prevent the expansion of horticultural production onto coffee land when unlimited credit was made available.

As shown in Table 20 the increase in credit expanded production

Table 19. Effect of additional credit on income and coffee production

Farm	Income			Coffee output		
	Present credit	Special credit	Extra credit	Present credit	Special credit	Extra credit
	-----colonos-----			-----fanegas-----		
1	19,781	19,781	19,781	82.8	82.8	82.8
2	18,025	18,025	18,025	193.2	193.2	193.2
3	35,543	35,543	35,543	750.0	750.0	750.0
4	31,667	32,178	34,722	225.0	225.0	225.0
5	16,877	16,877	16,877	190.0	190.0	190.0
6	-	-	-	76.0	76.0	76.0
7	7,147	7,669	8,300	62.0	67.5	95.0
8	4,005	4,406	4,662	19.0	19.4	28.5
9	86,761	89,296	105,524	997.2	993.5	662.5
10	29,489	35,716	40,557	213.3	192.2	71.0
11	24,536	26,960	26,986	100.0	100.0	100.0
12	7,078	23,641	26,605	22.5	8.7	0
13A	89,948	116,954	202,725	195.6	109.8	0
13B	67,694	67,694	67,694	900.0	900.0	900.0
14A	24,222	33,252	40,997	18.4	12.6	0
14B	16,718	17,470	17,470	70.0	70.0	70.0
15A	5,459	11,543	37,289	17.4	1.3	0
15B	5,209	5,209	5,209	20.0	20.0	20.0
16A	4,307	19,616	25,841	3.0	3.0	0
16B	3,612	6,307	6,307	9.0	15.0	15.0

Table 20. Optimal farm outputs of various crops on Alajuela farms given base capital and credit constraints and extra credit equaling ₡400 and ₡2,000 per manzana

Farm	Credit/mz.	Coffee (fanegas)	Sugarcane (toneladas)	Tomatoes (toneladas)	Strawberries (quintales)	Sweet- potatoes (quintales)	Limes (quintales)
9	Base	997.2	0	0	0	0	0
9	₡ 400	841.4	219.1	88.0	0	1,027.1	0
9	₡2,000	662.5	64.7	187.3	337.5	2,981.3	0
10	Base	213.3	148.0	48.0	0	708.0	0
10	₡ 400	188.9	208.2	77.0	0	833.0	0
10	₡2,000	71.0	188.6	109.0	289.3	1,994.2	0
11	Base	100.0	236.0	13.0	0	254.5	710.9
11	₡ 400	100.0	160.1	35.6	0	656.6	504.6
11	₡2,000	100.0	189.9	41.2	137.5	583.5	0
12	Base	22.5	0	0	0	0	717.2
12	₡ 400	22.5	177.5	17.6	0	189.9	0
12	₡2,000	0	166.2	76.3	66.7	825.0	0

of strawberries, tomatoes and sweetpotatoes on each of the four farms studied from Alajuela. Intermediate effects of lesser increases of credit were an expansion of sugarcane and a decrease in limes. Ups and downs in production occurred with sugarcane and sweetpotatoes as credit was increased. Sugarcane and tomatoes first replaced coffee and then higher increases in credit allowed strawberries and sweetpotatoes to be expanded as labor supervision became a limiting factor in certain months. This pattern was not the case on farm 11 because a lower labor supervision constraint was programmed. In that case, labor supervision blocked expansion of intensive horticultural crops before coffee output was affected. Those crops giving higher net returns per manzana than coffee required higher levels of labor as well as more short-run capital than was required for coffee production.

As shown in Table 21, the increase of credit availability also allowed intensive horticultural crops to substitute for coffee. Small increases in credit increased coffee output on the two farms which had the most land not planted to coffee and for which semi-abandoned coffee was part of the initial optimal solution. Coffee output was reduced to zero before labor supervisory restraints blocked the production of blackberries.

Subsidies for Alternatives

The payment of subsidies for the production of specific alternatives is also a possible policy measure. In general, results indicated that this was less efficient than disincentives for coffee production when the same results were obtainable. Subsidies for blackberries or strawberries had no effect on coffee acreage in those situations where part of the farm was not planted to coffee. Credit limited

Table 21. Optimal output of various crops on Acosta farms with high fruit prices given base capital and credit and extra credit equaling ¢400 and ¢2,000 per manzana

Farm	Credit/mz.	Coffee (fanegas)	Limes (quintales)	Blackberries (quintales)
13A	Base	195.6	17,780	0
13A	¢ 400	162.5	20,644	0
13A	¢2,000	0	36,607	1,402
14A	Base	18.4	3,600	0
14A	¢ 400	22.8	4,175	0
14A	¢2,000	0	5,695	294
15A	Base	17.4	106	0
15A	¢ 400	6.5	541	0
15A	¢2,000	0	463	135
16A	Base	3.0	382	0
16A	¢ 400	7.7	2,292	0
16A	¢2,000	0	1,350	500

berry production even when high prices were paid. For Alajuela, higher priced strawberries replaced tomatoes or limes in the model. Blackberries replaced limes or corn and beans in Acosta as prices were increased. The effect on coffee output was reduced yields as capital was transferred from coffee to berries or increased optimal acreage as credit limited coffee tree removal. Table 22 shows the effect of a blackberry subsidy on coffee output, and Table 23 shows the effect of a strawberry subsidy on coffee output.

With low fruit prices higher berry prices shifted resources from coffee but, with high fruit prices, resources were shifted to berry production from limes and increased coffee output occurred.

Stability of Alternative Crops

Lime production replaced coffee in two of eight farms when the lime price was programmed at ₡13.00 per quintal. Lime production occurred in the optimal resource use in six of the eight situations. Limes did not replace coffee when other land was available. The instability of lime production in the model when interest rates were increased indicates that long-term credit is required at subsidized rates. As shown in Table 24, no limes would be produced with a 14 percent long-term interest rate. Coffee was not removed when an interest rate of 10 percent was used in the program.

The prices of limes necessary to stimulate lime production in the model are given in Table 25. These prices are lower for Acosta farms than for Alajuela farms. The price required to stimulate coffee removal is also shown. Without extra credit the poorer farms could not replace coffee with limes at any price. A third price column

Table 22. The effect of a blackberry subsidy on optimal coffee output

Farm	Coffee output	
	No subsidy	Subsidy of ¢50 per quintal on blackberries
	(fanegas)	(fanegas)
13A	195.6	240.2
13B	900.0	900.0
14A	18.4	25.7
14B	70.0	26.0
15A	17.4	11.1
15B	20.0	19.5
16A	3.0	3.0
16B	9.0	9.0

Table 23. The effect of a strawberry subsidy on optimal coffee output

Farm	Coffee output	
	No subsidy	Subsidy of ¢100 per quintal of strawberries
	(fanegas)	(fanegas)
9	997.2	997.2
10	213.3	158.4
11	100.0	89.6
12	22.5	22.5

Table 24. Relationships between long-term interest rates and manzanas planted to limes

Farm	Interest rate in percent				
	6	8	10	12	14
	-----manzanas planted to limes-----				
9	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0
11	1.78	1.52	0.0	0.0	0.0
12	1.79	0.0	0.0	0.0	0.0
13A	44.45	16.44	11.50	11.50	0.0
14A	9.00	9.00	8.11	4.14	0.0
15A	0.26	0.0	0.0	0.0	0.0
16A	0.96	0.96	0.60	0.60	0.0

Table 25. Lime prices and lime production

Farm	Minimum price of limes per quintal		
	For production on any land	For production on coffee land	For a 25% increase in net returns
	-----colones-----		
9	19.37	19.37	23.40
10	14.45	14.45	16.27
11	12.05	14.80	15.34
12	12.90	a	15.34
13	9.73	11.81	12.70
14	10.31	14.56	12.08
15	10.64	10.64	14.18
16	10.68	a	13.54

^aCredit restrictions prevent planting coffee land to limes regardless of price.

gives the price necessary to increase farm net returns by 25 percent. This arbitrary level was chosen to illustrate that a difference may exist between changes that maximize net returns and changes that are significant enough to motivate action in the face of risk. These prices may be further modified by calculations to offset changes in the interest rate. Since the long-term investment is valued at ₡15,000 per manzana and the yield is 400 quintales of limes per manzana, each 1 percent increase in the rate of long-term interest would require the price of limes to be increased ₡0.375 per quintal. Thus, if a price of ₡12.00 must be paid to stimulate lime production given a 6 percent interest rate, the price must be increased to ₡13.50 per quintal if the same production is to occur with a 10 percent interest rate.

Limes compete well with lower-yielding coffee but the costs of production would be less on non-coffee land.

In Alajuela sweetpotatoes, peppers and tomatoes were priced at moderately high levels for processor use under the assumption that production would be on a contract basis for the Central American Common Market. The price estimates used were programmed downward to test the stability of the production of tomatoes and sweetpotatoes in the optimal solutions.

A 25 percent decrease in vegetable prices was accompanied by a shift to sugarcane, strawberry and peanut production on farm 10. Coffee acreage was reduced and sugarcane production was doubled. Output was comprised of 179.1 fanegas of coffee, 151.2 quintales of strawberries, 16.2 quintales of peanuts, 362.8 tons of sugarcane and 119.5 quintales of sweetpotatoes. A 36 percent decline in vegetable

prices blocked sweetpotato production. Strawberry output increased to 154.0 quintales and coffee output fell to 176.8 fanegas. Corn production replaced part of the sweetpotatoes. Sales included 38.3 quintales of corn, 16.1 quintales of peanuts and 369.7 tons of sugarcane. These parametric changes showed that strawberries may be a likely alternative despite their failure to appear in the optimal solution.

On farm 11, strawberries, peanuts and limes replaced sweetpotatoes and tomatoes when the prices of vegetables were programmed downward. With a 25 percent price decline for vegetables, the programmed output was 100.0 fanegas of coffee, 1.0 quintal of beans, 954.4 quintales of limes, 77.8 quintales of strawberries, 1.8 quintales of peanuts, 186.8 tons of sugarcane and 100.0 quintales of sweetpotatoes. With a further price decline to 50 percent of the vegetable prices, corn replaced sweetpotatoes. The programmed output was 100.0 fanegas of coffee, 25.0 quintales of corn, 887.1 quintales of limes, 82.1 quintales of strawberries, 7.6 quintales of peanuts and 196.9 tons of sugarcane. Income was reduced from ₡24,536 to ₡23,282 when the vegetable crops were excluded from the model.

Increases in orange prices resulted in oranges first substituting for limes and only affecting coffee production on the Alajuela and Acosta farms after other land was utilized. The orange enterprise was less competitive than limes, but if prices were stable above ₡6 per hundred, part of the resources could be rationally diverted from coffee to oranges.

Minimum prices that encourage orange production are shown in Table 26. The prices for orange production were calculated by adding

Table 26. Prices of oranges necessary to initiate orange production on farms in Alajuela and Acosta

Farm	Orange price per hundred	
	For orange production (colones)	For coffee substitution (colones)
9	7.24	7.24
10	5.82	5.82
11	5.25	5.99
12	4.57	6.27
13A	5.10	5.63
13B	4.11	4.25
14A	5.02	5.13
14B	4.08	5.07
15A	5.17	5.68
15B	4.50	4.50 ^a
16A	4.38	^a
16B	3.18	

^aCredit restriction blocks orange planting on coffee land regardless of price.

the parametric change to the initial price when an iteration brought oranges into the solution. The prices for coffee removal represent the price at the first iteration where either the coffee tree destruction activity entered the basis or a coffee production activity left the basis. Overestimation of price needed to initiate coffee removal could have occurred on those farms where coffee trees were removed in the initial optimal solution since a print-out was not called at every iteration.

The comparative profitability between oranges and limes are close enough to raise doubts as to the superiority of limes over oranges.

Comparative Costs of Coffee Removal

One means of evaluating the efficiency of various policy measures is to calculate the costs of removing one fanega of coffee. The base for comparisons is the farm price of coffee which estimates the costs of burning harvested coffee. The comparative costs are derived by dividing the reduction of income by the number of fanegas reduced.

Tables 27 through 34 show comparative costs for various methods of reducing coffee output on farms in the Palmares-San Ramón area. Higher costs for diversification were associated with higher coffee yields and greater reductions in coffee output. Even on farms 1 and 2 the costs of reducing coffee output were reduced if the released resources were put to alternative use. The cheapest means of reducing output was blocking new plantings but little output was affected. Credit reduction was not efficient since non-coffee crops were affected. Shifting non-land resources from coffee to alternative crops produced

Table 27. Alternative methods of reducing coffee output on farm 1

Method	Cost per fanega	Coffee reduction	
		Fanegas	Percent
Burning coffee	¢ 203.31	82.8	100.0
Credit reduction (70%)	2,446.40	3.7	4.5
Mandatory abandonment ^a	158.72	27.6	33.3
Mandatory semi-abandonment ^a	155.06	23.6	28.5
Mandatory traditional output ^a	154.37	18.6	22.5
Tree removal and diversification	115.30	5.0	6.0
Tree removal and diversification	120.63	10.0	12.1

^aCosts were calculated with one manzana shifted to less-intensive production as other production was held constant.

Table 28. Comparative costs of various methods of coffee output reduction on farm 2

Method	Cost per fanega	Coffee reduction	
		Fanegas	Percent
Credit reduction (25%)	¢135.86	8.2	4.2
Credit reduction (30%)	135.86	18.7	9.7
Credit reduction (50%)	135.86	60.5	31.3
Credit reduction (70%)	137.08	102.4	53.0
Burning coffee	203.31	193.2	100.0
Mandatory abandonment ^a	137.22	27.6	14.3
Mandatory semi-abandonment ^a	135.86	23.6	12.2
Mandatory traditional output ^a	135.95	18.6	9.6
Tree removal and diversification	91.02	10.0	5.2
Tree removal and diversification	91.02	20.0	10.4
Tree removal and diversification	91.02	40.0	20.7

^aCalculated by shifting one manzana of coffee to less-productive use holding other production constant.

Table 29. Alternative methods of reducing coffee output on farm 3

Method	Cost per fanega	Coffee reduction	
		Fanegas	Percent
Reduced credit (50%)	¢236.22	29.7	4.0
Reduced credit (60%)	119.24	130.0	17.3
Burning coffee	203.31	750.0	100.0
Mandatory abandonment ^a	101.62	15.0	2.0
Mandatory semi-abandonment ^a	92.37	11.0	1.4
Mandatory traditional output ^a	59.80	6.0	0.8
Tree removal and diversification	36.36	80.8	10.8
Tree removal and diversification	37.12	86.1	11.5
Tree removal and diversification	47.48	287.2	38.3
Tree removal and diversification	51.84	485.8	64.8

^aCalculated by shifting one manzana of coffee to a less-productive use holding other production constant.

Table 30. Alternative methods of reducing coffee output on farm 4

Method	Cost per fanega	Coffee reduction	
		Fanegas	Percent
Reduced credit (10%)	¢220.52	5.4	2.4
Reduced credit (30%)	132.50	31.4	14.0
Reduced credit (60%)	191.80	50.3	22.4
Reduced credit (90%)	180.42	94.0	41.8
Burning coffee	203.31	225.0	100.0
Mandatory abandonment ^a	109.35	15.0	6.7
Mandatory semi-abandonment ^a	103.10	11.0	4.9
Mandatory traditional output ^a	112.38	6.0	2.6
Shifting operating capital	16.32	2.9	1.3
Shifting operating capital	27.06	33.0	14.7
Shifting operating capital	37.96	68.4	30.4
Tree removal	37.64	3.6	1.6
Tree removal	40.28	4.1	1.8
Tree removal	60.24	33.0	14.7
Tree removal	68.23	56.2	25.0
Tree removal	94.90	225.0	100.0
Price differentiation	164.76	33.0	14.7

^aCalculated by shifting one manzana of coffee to less-productive use holding other production constant.

Table 31. Comparative costs of various methods of reducing coffee output on farm 5

Method	Cost per fanega	Coffee reduction	
		Fanegas	Percent
Burning coffee	¢203.31	190.0	100.0
Credit reduction (25%)	112.21	7.3	3.8
Credit reduction (50%)	112.21	46.6	24.5
Credit reduction (70%)	112.83	79.2	41.7
Credit reduction (90%)	115.69	118.9	62.6
Mandatory abandonment ^a	127.24	19.0	10.0
Mandatory semi-abandonment ^a	120.03	15.0	7.9
Mandatory traditional output ^a	112.21	10.0	5.3
Tree removal and diversification	57.81	23.5	12.4
Tree removal and diversification	60.72	42.4	22.3
Tree removal and diversification	61.55	47.3	24.9
Tree removal and diversification	66.19	59.6	29.9
Tree removal and diversification	72.04	77.6	40.8
Tree removal and diversification	75.51	110.8	58.3
Tree removal and diversification	79.71	142.0	74.7

^aCalculated by shifting one manzana of coffee to a less-productive use while holding other production constant.

Table 32. Comparative costs of various methods of reducing coffee output on farm 6

Method	Cost per fanega	Coffee reduction	
		Fanegas	Percent
Burning coffee	¢203.31	76.0	100.0
Credit reduction (50%)	7.62	4.7	6.2
Credit reduction (60%)	79.96	13.1	17.2
Credit reduction (70%)	93.82	23.0	30.2
Credit reduction (80%)	99.35	32.7	43.0
Credit reduction (90%)	102.72	42.9	56.4
Mandatory abandonment ^a	126.93	19.0	25.0
Mandatory semi-abandonment ^a	119.49	15.0	19.7
Mandatory traditional output ^a	112.21	10.0	13.2
No new planting	4.13	4.7	6.2
Tree removal and diversification	49.94	32.4	42.6
Tree removal and diversification	57.19	76.0	100.0

^aCalculated by shifting one manzana of coffee to a lower-yielding use holding other production constant.

Table 33. Comparative costs of various methods of reducing coffee output on farm 7

Method	Cost per fanega	Coffee reduction	
		Fanegas	Percent
Burning coffee	¢203.31	62.0	100.0
Credit reduction (5%)	15.83	5.0	8.1
Credit reduction (55%)	399.74	5.8	9.4
Credit reduction (60%)	341.10	8.7	13.1
Credit reduction (70%)	325.08	13.1	21.1
Credit reduction (75%)	266.70	18.6	30.0
Mandatory abandonment ^a	118.13	19.0	30.6
Mandatory semi-abandonment ^a	117.64	15.0	24.1
Mandatory traditional output ^a	197.73	10.0	16.1
No new planting	0.46	5.0	8.1
Diversification of non-land resources	63.70	16.2	26.1
Tree removal and diversification	93.88	38.1	61.4
Tree removal and diversification	95.47	40.2	64.8
Tree removal and diversification	106.59	62.0	100.0

^a Calculated by shifting one manzana of coffee to less-productive use holding other production constant.

Table 34. Comparative costs of various methods of reducing coffee output on farm 8

Method	Cost per fanega	Coffee reduction	
		Fanegas	Percent
Burning coffee	¢203.31	19.0	100.0
Credit reduction (35%)	1,183.43	0.8	4.2
Credit reduction (50%)	339.40	4.1	21.6
Credit reduction (60%)	234.15	8.5	44.7
Credit reduction (75%)	222.93	9.7	51.1
Credit reduction (100%)	265.02	15.0	78.9
Tree removal	135.59	19.0	100.0
Mandatory abandonment ^a	151.24	19.0	100.0
Mandatory semi-abandonment ^a	143.49	15.0	78.9
Mandatory traditional output ^a	136.21	10.0	52.6
Diversification of capital use	15.39	1.5	7.9
Diversification of capital use	60.72	5.0	26.3
Price differentiation	80.71	1.5	7.9

^aCalculated by shifting one manzana of coffee to a less-productive use holding other production constant.

low cost reductions in coffee output. Direct output control was cheaper than credit reduction on all farms. If coffee trees were removed, then the cost per fanega of reduced coffee output could be lessened 25 to 65 percent by shifting resources into alternative uses. The shifting of non-land resources was a cheap way of reducing coffee output when excess tobacco allotment was available.

In Alajuela the costs of coffee removal were highest for the smallest farm where the credit restriction blocked the use of higher-yielding alternative crops. Normally, the cost per fanega of reduced coffee output was increased as larger quantities of coffee were taken out of production. However, in the cases where subsidy payments for other crops first shifted resources from the production of a non-coffee crop to the subsidized crop, the average cost per fanega of coffee removal was higher when only a small percentage of the coffee output was affected. Subsidy payments were expensive means of coffee reduction since non-coffee land was first planted to the subsidized crop. Credit reduction affected the output of other crops before it affected coffee on farms 10, 11 and 12.

Tables 35 through 38 show comparative costs of removing one fanega of coffee through various methods on the Alajuela farms. Since print-outs were not called for at every iteration of parametric change, only part of the levels of change are given. Nevertheless, the comparative costs indicate that the cheapest method of controlling coffee output would be carried out with resource reallocation after some direct control of output. An annual subsidy for coffee tree removal gives slightly higher removal costs on two of the farms which indicates that other factors are more easily shifted out of coffee

Table 35. The comparative costs of various methods of reducing coffee output on farm 9

Method	Cost per fanega	Coffee reduction	
		Fanegas	Percent
Burning coffee	¢196.73	997.2	100.0
Credit reduction (10%)	109.96	62.2	6.2
Credit reduction (20%)	110.92	126.6	12.7
Credit reduction (30%)	112.49	195.2	19.6
Credit reduction (50%)	113.69	332.5	33.3
Credit reduction (70%)	116.96	512.0	51.3
Subsidize oranges (¢3.98/100)	99.01	709.5	71.2
Subsidize limes (¢6.37/qq.)	63.46	259.9	26.1
Subsidize limes (¢7.95/qq.)	67.26	666.6	66.8
Coffee tree removal	43.54	171.5	17.2
Coffee tree removal	43.91	180.7	18.1
Coffee tree removal	51.92	309.7	31.1
Coffee tree removal ^a	67.00	454.8	45.6
Mandatory abandonment ^a	117.90	25.0	2.5
Mandatory semi-abandonment ^a	114.63	21.0	2.1
Mandatory traditional output ^a	119.52	16.0	1.6
Resource reallocation	43.39	176.2	17.7
Resource reallocation	43.67	183.9	18.4
Resource reallocation	49.51	317.2	31.8
Resource reallocation	54.31	452.0	45.3

^aCalculated by shifting one manzana from highest technology to a lower level of output holding other production constant.

Table 36. The comparative costs of various methods of reducing coffee output on farm 10

Method	Cost per fanega	Coffee reduction	
		Fanegas	Percent
Burning coffee	¢196.73	213.3	100.0
Mandatory abandonment ^a	114.77	20.0	9.4
Mandatory semi-abandonment ^a	114.02	16.0	7.5
Mandatory traditional output ^a	115.55	11.0	5.2
Subsidize pineapples (¢114.91/T.)	181.15	17.9	8.4
Subsidize pineapples (¢156.45/T.)	311.63	58.6	27.5
Subsidize oranges (¢1.96/100)	121.69	141.3	66.2
Subsidize oranges (¢4.98/100)	159.53	213.3	100.0
Subsidize strawberries (¢36.22/qq.)	71.64	26.8	12.6
Subsidize strawberries (¢55.55/qq.)	67.65	32.9	15.4
Subsidize strawberries (¢97.74/qq.)	68.52	55.0	25.8
Subsidize limes (¢1.87/qq.)	46.93	141.3	66.2
Subsidize limes (¢3.85/qq.)	57.58	213.3	100.0
Coffee tree removal (¢572/mz.)	24.03	26.1	12.2
Coffee tree removal (¢789/mz.)	31.84	71.3	33.4
Coffee tree removal (¢879/mz.)	36.77	141.3	66.2
Coffee tree removal (¢1,588/mz.)	38.34	149.5	70.1
Resource reallocation	23.23	15.7	7.4
Resource reallocation	24.03	26.1	12.2
Resource reallocation	36.61	141.3	66.2
Resource reallocation	40.41	171.0	80.2
Resource reallocation	46.70	192.1	90.1

^aCalculated by shifting one manzana of coffee to a less-productive use holding other production constant.

Table 37. The comparative costs of various methods of reducing coffee output on farm 11

Method	Cost per fanega	Coffee reduction	
		Fanegas	Percent
Burning coffee	¢196.73	100.0	100.0
Reduced credit (40%)	409.66	7.9	7.9
Reduced credit (50%)	321.29	16.5	16.5
Reduced credit (60%)	355.79	24.3	24.3
Reduced credit (70%)	630.12	19.5	19.5
Mandatory abandonment ^a	100.35	20.0	20.0
Mandatory semi-abandonment ^a	109.03	16.0	16.0
Mandatory traditional output ^a	124.46	11.0	11.0
Subsidize oranges (¢2.92/cien)	177.25	100.0	100.0
Subsidize pineapples (¢296.96/T.)	480.37	36.7	36.7
Subsidize strawberries (¢60.02/qq.)	335.16	10.4	10.4
Subsidize limes (¢1.80/qq.)	148.15	5.0	5.0
Subsidize limes (¢3.74/qq.)	74.93	98.0	98.0
Coffee tree removal (¢958/mz.)	47.68	20.6	20.6
Coffee tree removal (¢1,124/mz.)	51.67	86.1	86.1
Resource reallocation	43.32	0.6	0.6
Resource reallocation	47.68	20.6	20.6
Resource reallocation	51.53	83.7	83.7
Resource reallocation	52.92	100.0	100.0

^aCalculated by shifting one manzana of coffee to a less-productive use holding other production constant.

Table 38. The comparative costs of various methods of reducing coffee output on farm 12

Method	Cost per fanega	Coffee reduction	
		Fanegas	Percent
Burning coffee	¢196.73	22.5	100.0
Credit reduction (70%)	1,478.38	2.4	10.7
Subsidize oranges (¢1.93/100)	1,735.24	1.3	5.7
Subsidize limes (¢3.10/qq.)	62.60	12.5	55.6
Coffee tree removal (¢3,231.95/mz.)	359.11	12.2	54.2
Mandatory abandonment ^a	137.37	9.0	40.0
Mandatory semi-abandonment ^a	127.48	5.0	22.2
Resource reallocation	62.60	12.5	55.6

^aCalculated by shifting one manzana of coffee to less-productive use holding other production constant.

production than is land. As in the Palmares-San Ramón area the larger reductions in output are generally associated with higher costs.

On the Acosta farms studied the initial optimal coffee production was much lower when high fruit prices were used than when low fruit prices were used. As a result, the responses to parametric changes and comparative costs of reducing coffee output from the initial optimal production also differed.

When high fruit prices were used, coffee trees were removed in the two farm situations where other land was not available. When other land was available, coffee yields were reduced as non-land resources were shifted from coffee to limes.

Comparative costs of reducing coffee output on the Acosta farms are given in Tables 39 through 42. These costs represent the costs of reducing the initial programmed optimal coffee output and not the output reported for the farms under current practices. Lower costs for coffee removal on farm 13 reflected greater ease in shifting to limes because credit was not as restricted as in the other farm situations. Credit restrictions limited the ability of farm 16 to respond with alternative crops when price or other incentives encouraged the reduction of coffee output.

When low fruit prices were used to represent the alternative relationships without local processing in the Acosta area, the production of coffee approximated the reported production on the farms studied. With the lower fruit prices, the initial optimal output of coffee was higher than when high fruit prices were used. The comparative costs per fanega of coffee output reduction is given for various policy measures in Tables 43 through 46. The cheapest method of

Table 39. The comparative costs of various methods of reducing coffee output on farm 13, given high fruit prices

Method	Cost per fanega	Coffee reduction	
		Fanegas	Percent
Burning coffee	¢215.20	195.6	100.0
Mandatory abandonment ^a	111.37	6.0	3.1
Mandatory semi-abandonment ^a	110.35	4.0	2.0
Subsidize limes (¢1.71/qq.)	19.67	66.7	34.1
Subsidize limes (¢4.48/qq.)	24.86	88.8	45.4
Coffee tree removal (¢382.60/mz.)	14.37	62.5	32.0
Coffee tree removal (¢684.61/mz.)	19.67	66.7	34.1
Coffee tree removal (¢1,260.34/mz.)	24.86	88.8	45.4
Resource reallocation	14.37	62.5	32.0
Resource reallocation	21.60	87.7	44.8

^aCalculated by shifting one manzana of the best coffee to less-productive use holding other production constant.

Table 40. The comparative costs of various methods of reducing coffee output on farm 14, given high fruit prices

Method	Cost per fanega	Coffee reduction	
		Fanegas	Percent
Burning coffee	¢215.20	18.4	100.0
Subsidize oranges (¢1.91/qq.)	1,492.11	8.6	46.7
Subsidize limes (¢2.39/qq.)	43.55	5.0	27.2
Subsidize blackberries (¢20.53/qq.)	50.41	4.4	23.9
Mandatory abandonment ^a	131.97	6.0	32.6
Mandatory semi-abandonment ^a	131.95	4.0	21.7
Mandatory abandonment ^b	145.00	2.0	10.9
Coffee tree removal (¢625.02/mz.)	26.49	4.8	26.1
Coffee tree removal (¢947.53/mz.)	43.55	5.0	27.2
Coffee tree removal (¢1,389.54/mz.)	335.23	6.2	33.7
Resource reallocation	26.49	4.8	26.1

^aCalculated by shifting one manzana of the best coffee to less-productive use holding other production constant.

^bCalculated by abandonment of one manzana of semi-abandoned coffee holding other production constant.

Table 41. The comparative costs of various methods of reducing coffee output on farm 15, given high fruit prices

Method	Cost per fanega	Coffee reduction	
		Fanegas	Percent
Burning coffee	¢215.20	17.4	100.0
Reduce credit (50%)	428.89	1.7	9.8
Reduce credit (60%)	273.83	3.4	19.5
Reduce credit (70%)	220.70	5.0	28.7
Subsidize oranges (¢1.68/100)	117.53	10.2	58.6
Subsidize blackberries (¢24.29/qq.)	58.76	6.2	35.6
Subsidize blackberries (¢85.20/qq.)	76.46	13.7	78.7
Subsidize limes (¢1.77/qq.)	28.74	9.2	52.9
Subsidize limes (¢7.24/qq.)	46.90	14.9	85.6
Mandatory abandonment ^a	135.26	10.0	57.5
Mandatory semi-abandonment ^a	121.15	8.0	46.0
Coffee tree removal (¢711.34/mz.)	28.74	9.2	52.9
Resource reallocation	28.74	9.2	52.9
Resource reallocation	46.90	14.9	85.6

^a Calculated by shifting one manzana of coffee to a less-productive use holding other production constant.

Table 42. The comparative costs of various methods of reducing coffee output on farm 16, given high fruit prices

Method	Cost per fanega	Coffee reduction	
		Fanegas	Percent
Burning coffee	¢ 215.20	3.0	100.0
Mandatory abandonment ^a	185.70	2.0	66.7
Tree removal (¢3,645.77/mz.)	1,822.89	1.4	46.7
Tree removal (¢4,200.65/mz.)	1,927.17	2.3	76.7

^aCalculated by shifting one manzana of coffee into abandonment holding other production constant.

Table 43. The comparative costs of various methods of reducing coffee output on farm 13, given low fruit prices

Method	Cost per fanega	Coffee reduction	
		Fanegas	Percent
Burning Coffee	¢215.20	900.0	100.0
Credit reduction (10%)	75.41	32.0	3.6
Credit reduction (30%)	77.03	181.3	20.1
Credit reduction (50%)	81.38	323.6	36.0
Credit reduction (70%)	81.21	493.2	54.8
Mandatory abandonment ^a	82.22	10.0	1.1
Mandatory semi-abandonment ^a	74.92	8.0	0.9
Subsidize oranges (¢1.96/100)	115.11	54.2	6.0
Subsidize oranges (¢2.91/100)	129.33	813.2	90.4
Subsidize limes (¢2.81/qq.)	140.57	45.7	5.1
Subsidize limes (¢5.71/qq.)	71.20	771.1	85.7
Coffee tree removal (¢184.00/mz.)	17.72	86.0	9.6
Coffee tree removal (¢577.06/mz.)	31.94	305.8	34.0
Resource reallocation	14.24	14.1	1.6
Resource reallocation	17.72	86.0	9.6
Resource reallocation	31.94	305.8	34.0
Resource reallocation	35.20	416.0	46.2
Resource reallocation	49.15	733.8	81.5

^aCalculated by shifting one manzana of coffee land to less-productive use holding other production constant.

Table 44. The comparative costs of various methods of reducing coffee output on farm 14, given low fruit prices

Method	Cost per fanega	Coffee reduction	
		Fanegas	Percent
Burning coffee	¢215.20	70.0	100.0
Reducing credit (10%)	107.16	6.9	9.9
Reducing credit (20%)	110.31	14.2	20.3
Reducing credit (30%)	238.28	17.1	24.4
Reducing credit (50%)	254.97	17.9	25.6
Reducing credit (70%)	343.40	21.2	30.3
Subsidize limes (¢2.91/qq.)	133.73	51.6	73.7
Subsidize limes (¢5.56/qq.)	130.35	56.4	80.6
Subsidize oranges (¢2.91/100)	279.20	60.3	86.1
Subsidize blackberries (¢71.60/qq.)	305.80	39.7	56.7
Mandatory abandonment ^a	107.71	10.0	14.3
Mandatory semi-abandonment ^a	106.29	8.0	11.4
Coffee tree removal (¢959.66/mz.)	88.34	7.5	10.7
Coffee tree removal (¢1,176.52/mz.)	95.41	24.7	35.3
Coffee tree removal (¢1,746.27/mz.)	129.54	53.7	76.7
Resource reallocation	4.78	0.2	0.3
Resource reallocation	8.32	3.4	4.9
Resource reallocation	9.00	3.7	5.3
Resource reallocation	19.78	9.9	14.1
Resource reallocation	31.42	14.8	21.1
Resource reallocation	37.81	18.3	26.1
Resource reallocation	71.49	44.4	63.4

^aCalculated by shifting one manzana of coffee to less-productive use holding other production constant.

Table 45. The comparative costs of various methods of reducing coffee output on farm 15, given low fruit prices

Method	Cost per fanega	Coffee reduction	
		Fanegas	Percent
Burning coffee	¢215.20	20.0	100.0
Reduce credit (30%)	112.17	1.1	5.5
Reduce credit (50%)	112.18	4.4	22.0
Reduce credit (70%)	112.17	7.7	38.5
Mandatory abandonment ^a	135.26	10.0	50.0
Mandatory semi-abandonment ^a	121.15	8.0	40.0
Subsidize oranges (¢1.50/100)	153.32	3.6	18.0
Subsidize oranges (¢2.68/100)	138.07	12.9	64.5
Subsidize limes (¢1.64/qq.)	65.62	2.6	13.0
Subsidize limes (¢.78/qq.)	87.14	11.8	59.0
Coffee tree removal (¢581.00/mz.)	58.10	3.2	16.0
Coffee tree removal (¢1,444.93/mz.)	91.35	5.2	26.0
Coffee tree removal (¢1,748.73/mz.)	96.96	14.2	71.0
Resource reallocation	58.10	3.2	16.0
Resource reallocation	80.02	12.4	62.0

^aCalculated by shifting one manzana of coffee to less-productive use holding other production constant.

Table 46. The comparative costs of various methods of reducing coffee output on farm 16, given low fruit prices

Method	Cost per fanega	Coffee reduction	
		Fanegas	Percent
Burning coffee	¢215.20	9.0	100.0
Reduce credit (50%)	438.77	2.7	30.0
Reduce credit (60%)	280.88	5.2	57.8
Reduce credit (70%)	309.17	6.0	66.7
Mandatory abandonment ^a	152.32	6.0	66.7
Mandatory semi-abandonment ^a	135.63	4.0	44.4
Subsidize oranges (¢1.60/100)	557.39	6.0	66.7
Subsidize limes (¢3.02/qq.)	139.04	6.0	66.7
Subsidize limes (¢5.01/qq.)	321.07	6.0	66.7
Coffee tree removal	251.82	7.4	82.2
Coffee tree removal	441.31	8.3	92.2
Resource reallocation	31.57	4.3	47.8
Resource reallocation	43.34	6.0	66.7

^aCalculated by shifting one manzana of coffee to less-productive use holding other production constant.

reducing coffee output was to allow resources to be shifted to corn and beans. Where land was initially all in coffee, coffee removal subsidies were equally effective as direct controls. Subsidizing orange or lime production was over twice as costly as allowing resources to shift to corn and beans. Small quantities of coffee could be replaced with corn and beans at less than 10 percent of the cost of destroying harvested coffee on farms 13 and 14. More restricted credit made it more costly to replace coffee on the smaller farms.

The following generalizations were drawn from the cost comparisons:

1. Diversified use of resources for the production of alternative crops was a much cheaper means of reducing coffee output than either destroying harvested coffee or restricting short-term credit without selectivity.

2. Blocking new coffee plantings was the cheapest means of reducing programmed optimal coffee production.

3. Subsidizing coffee tree removal was relatively efficient on farms with all land planted to coffee but less efficient on previously diversified farms as a means of coffee production control.

4. Subsidizing alternative crops was efficient as a means of coffee control only if the best alternative was chosen and no non-coffee land was available. Distortions in the balance of resources occurred when strawberries or blackberries were subsidized without provisions for extra credit and in some cases actually increased programmed coffee output.

5. In those farm situations where land was available that was not planted to coffee, the cheapest reduction in coffee output accompanied a shift of non-land resources from coffee to alternatives.

SUMMARY AND CONCLUSIONS

When this study was initiated in 1967, Costa Rica faced a serious and immediate threat of overproduction of coffee. Although unfavorable weather conditions in Brazil reduced the world surplus in the 1968-1969 harvest season, the threat of future overproduction still exists.

Since farm management decisions affecting the quantity of coffee produced are made by the farm operators, expansion or curtailment of coffee production will depend upon decisions made by individual farmers. With this point in view, the purpose of this study was to evaluate the farm income opportunities resulting from the production of coffee and alternative farm products. Comparisons between programmed optimal resource use and actual reported resource use were also used to test the hypothesis that these farmers react to price and cost stimuli in order to maximize net income. In addition, the effects of multiple pricing of coffee, changes in interest rates and credit, subsidy programs and other policy measures were evaluated with respect to net income and coffee production. Linear and parametric programming were the principal analytical techniques used in the analysis. A total of 16 farms representing different resource situations in three different areas of Costa Rica were used in the analysis.

Effects of Improved Resource Allocation

Programmed resource allocation to maximize profits caused some

shifting of cropping patterns. Nevertheless, given traditional alternatives, the stability of coffee acreage was assured by high costs of planting and of destroying coffee. While some farms did overproduce coffee, others underproduced in relation to optimum output. Although the net effect was to reduce coffee slightly on those farms included in this study, the reduction occurred only on two of the 16 farms. Therefore, the optimal allocation of resources would not reduce coffee production significantly when traditional crops are considered.

This result lends support to Shultz's hypothesis (63, p. 14) that producers in underdeveloped countries do attempt to maximize profits and do allocate given resources efficiently. However, the high returns to additional credit, the entrance of new crops into the model, and the apparent misallocation of resources on certain farms indicate that the Costa Rican farms studied are more representative of transitional than of traditional agriculture.

On the farms studied, farmer allocation of resources used for other crops was, for the most part, less efficiently managed than those used to produce coffee. The only major reallocation of coffee resources occurred on the farms specializing in flue-cured tobacco. Thus, comparisons between reported and optimal resource use showed a concentration of managerial effort in the major cash crops. Although education and extension work may be expected to increase the efficiency of production of alternative crops, the expansion of traditional food crops does not offer an incentive for reductions in coffee production.

On the other hand, horticultural crops and sugarcane may compete effectively for some resources going to coffee. The production of limes could pull resources away from coffee if subsidized long-term credit were made available and prices were stabilized with long-term

contracts. Considerable training and farmer education would also be required. Limes would compete more favorably with low-yielding coffee or corn and beans than with high-yielding coffee, vegetable crops or sugarcane.

Vegetable crops could potentially receive resources shifted out of coffee in the Alajuela area. However, it was noted that vegetable crops competed more closely with sugarcane and strawberries than with coffee. When tomatoes and sweetpotatoes replaced sugarcane and beans, coffee output was not reduced by diversification. Since the risks and managerial requirements of vegetable production greatly exceed those of sugarcane production, the programmed higher returns to vegetable production may not be great enough to motivate change in that direction.

In summary, while the maximization of profits may cause some changes in production patterns, a reduction in coffee output requires additional action if significant changes are to be made.

Effects of Taxes or Price Declines

The stability of coffee production under declining prices caused farm incomes to be reduced drastically before output was curtailed. The specialized coffee farms incurred the greatest percentage reduction of income when prices declined. A small tax of ₡5.00 or ₡10.00 per fanega was ineffective in reducing coffee production. A price decline of ₡50 per fanega reduced net income over 50 percent on many coffee farms.

The supported price in the traditional coffee market was roughly 25 percent higher than the price in the rest of the world in 1967.

Prices for coffee without the coffee agreement could be expected to fall 30 to 50 percent. If this were to happen, serious losses would occur on many specialized farms and few coffee farms could maintain net incomes at half of the present level.

When price declines occurred to levels representative of new coffee market export prices, coffee output was reduced on most farms. This indicates that from a national viewpoint some resources are misallocated into coffee production. However, the coffee output of some of the farms, including those with highest yields, was not reduced when the coffee price was lowered to new market levels. Also most of the farms studied produced more than 75 percent of their initial optimal coffee output at this price. This indicates that part of the resources going into coffee sold in the new market are not being misallocated.

Effects of Credit Reduction

A policy of reducing annual credit would reduce both incomes and crop production. Incomes of those farms with intensive alternative crops would be affected most adversely. Returns are high enough to enable coffee producers to go into unofficial money markets since the marginal returns to credit exceed 100 percent in those cases where short-term credit limits coffee output. This policy would be effective only against farmers who are unable to borrow from non-bank sources because of low credit standing, and therefore would be selective against poorer, smaller farmers. Incomes on these small diversified farms would be less adversely affected by policies of taxation or coffee burning than by credit restrictions. A general credit reduc-

tion would lower coffee production but would not divert resources from coffee to alternative uses.

Effects of Price Differentiation

Theoretically, a two-price program would equate the marginal return of the farmer with the marginal return of the country and would avoid overallocation of resources to coffee. In practice, difficulties will arise because the base used to establish the quota for the higher-priced market may differ from optimal coffee output. It is likely that those farms with below optimal historical production would oppose the policy as it would lower the average price of their optimal production. Those farms with a higher historical base than justified by profit maximization would benefit without necessarily lowering production beyond the level that gives maximum net returns without the policy measure. Another major difficulty from a political standpoint is that the gains derived from shifting resources out of coffee are not high. Also, in situations where technological advances in horticultural crops may cause a shifting of resources out of coffee, there might be a retardation of this shift. Price differentiation would be effective in reducing the production of coffee only if alternatives surpass new market coffee in earning ability. Major opposition may be expected from farms where modernization of coffee technology is underway. As with production control policies in the United States, the most often heard criticism is that the plan thwarts technological change. This criticism is not justified since production for the new markets is allowed.

In summary, this policy could reduce coffee output and increase

farm income from the levels of the base period. However, it may be argued that technological change involving new credit for alternative crops can increase income and reduce coffee production more. If this is true, price differentiation could slow diversification in periods of rapid transition.

Effects of Increased Credit

Increased credit may lead to an increase in coffee production on some farms and to a decrease on other farms. Intensive alternative crops giving higher net returns per manzana than coffee are required before this measure aids diversification. Where fruit and vegetable crops can be marketed, the expansion of credit could both increase income and reduce coffee output. There are situations in which income could be doubled, tripled or quadrupled by increased credit availability. However, the production of horticultural crops for industrial utilization requires new skills and technology and close supervision. It also involves greater risk in comparison with coffee. The expansion of credit is likely to be effective only if it is accompanied by education and supervision. It may be that only the more efficient coffee producers can adopt the more complicated managerial techniques needed for fruit and vegetable production. Even high-yielding coffee can be replaced on land suited for vegetable and fruit production if prices are stable and extra credit is made available. However, since the markets for these horticultural commodities are small, expansion may be limited to non-coffee land.

Increased credit brought an expansion of strawberries, sugarcane, sweetpotatoes and tomatoes into the model situations in Ajuela.

Whether these crops or other crops such as peppers or pickles are grown will depend upon the contracts available for particular crops. The reduced shadow prices of excluded horticultural production enterprises indicated greater ease of substitutability of one vegetable for another as more credit becomes available. In the Acosta situations with high fruit prices, the production of limes and blackberries was expanded. As in Alajuela, the removal of coffee was profitable only when the demand for alternatives was sufficient to exhaust non-coffee land.

The Choices of Alternative Crops

Different alternatives were represented in the three zones of coffee production studied. In the Palmares-San Ramón area, income from tobacco production rivaled that of coffee. However, since tobacco production was limited by contractual arrangements, the best expandable alternatives consisted of beans, sesame, corn and beans, and mixed crops. Dairy replaced part of the lower-yielding coffee in the analysis as coffee price was lowered. Generally, the first shift, as prices of coffee were reduced, was to beans. Production patterns became more complex with diversification. Credit reduction, which occurred as coffee was removed, shifted production towards subsistence crops. This result caused different crops to be considered as higher amounts of coffee were shifted out of production. Firstly, higher-yielding corn, beans and sesame were considered. However, as prices of coffee fell, credit was limited. Then castorbeans and lower-yielding corn, bean and sesame activities were relatively more profitable. It may be noted that, given ample credit, corn, beans and

sesame were poor substitutes for tobacco and coffee. However, on the poorer farms or under reduced credit, low-yielding sesame and broadcast beans were among the most profitable alternatives.

The manner in which change is motivated also has an influence on which crops are produced. A credit reduction favors semi-abandoned coffee and primitively grown beans and sesame. Taxation or a price decline would first substitute the highest-yielding corn, bean or sesame alternatives but greater coffee price declines would be accompanied by a shift to traditional food crop activities. An annual payment for coffee tree removal would tend to shift land ahead of other resources and encourage less intensive production alternatives.

In Alajuela, vegetable crops and sugarcane compete favorably with established coffee that yields 20 fanegas per manzana or less. However, credit restrictions and market limitations make large-scale changes in resource allocation uneconomical. Tomatoes and sweetpotatoes showed the most potential as substitutes for coffee in the model but relatively small price fluctuations could bring peppers, strawberries, cucumbers and other vegetables into production. Sugarcane also competed for resources shifted from coffee. As prices were reduced, sugarcane replaced high-yielding coffee on the largest farm studied. A difference in resource allocation occurred with price declines with specific results depending upon the efficiency of coffee production and credit limitations. Sugarcane was favored over vegetables when the permanent labor supply was exhausted and limes were favored over vegetables when short-term credit was more limited.

When credit was increased, strawberry, sweetpotato and tomato production increased. When credit was reduced severely, semi-abandoned

coffee and traditional crops of corn and beans became the most profitable activities.

The expansion of horticultural crops depends upon stable high prices for industrial use. Fresh fruit and vegetables for the domestic market receive much higher prices but also face considerable risk. These combinations of high average prices and high risks have checked modernization of technology. Conservative management policy cuts input cost to minimize loss in years of low prices or at least to hold risks to some acceptable level. This interplay of risks and profits in decision-making processes cause actual resource use to deviate from long-run profit maximization. An additional factor of small market size also affects decision making. Each of a few producers may be able to influence price; therefore, the high domestic price levels were not used in the analysis of fruit and vegetable alternatives. Opposition to policies favoring the industrialization of horticultural products may be expected from fruit and vegetable producers currently serving the fresh produce market.

In Acosta, high fruit prices brought large shifts in resources from coffee to limes. Blackberries could be encouraged by increased credit in addition to stable high industrial prices. Additional changes to be brought about by other policy measures would be slow to occur and relatively unimportant.

When low fruit prices were used in the analysis, coffee was replaced by corn and beans with moderately small declines in the coffee price. Poor yielding coffee could be removed by taxation or market price declines. But the short-run best allocation of resources would be disastrous over a long time period. The topography is rough

and unsuited to row crops. Erosion and leaching of soils exposed to heavy rains would bring a continuing decline of productivity to farms in the Acosta area.

Comparative Costs of Coffee Removal

The costs of reducing optimal coffee output using various policy measures were calculated for 20 farm situations. Wide differences occurred from farm to farm and among methods.

In general, low-yielding coffee was cheaper to remove than high-yielding coffee. However, the costs of coffee reduction increased as the quantity reduced on a particular farm increased. The productivity of the alternatives also entered into the costs of reducing coffee output. For example, it was cheaper to remove 25 fanegas per manzana of coffee from an Alajuela farm with horticultural crops among its alternatives than to remove 19 fanegas per manzana of coffee from a farm in Palmares with poorer alternative possibilities. Credit restrictions on poorer farms blocked higher return alternatives and raised the comparative costs of reducing coffee above the costs of reducing better yielding coffee on more profitable farms. Small reductions in coffee output were made most cheaply on average or lower yielding farms. However, when larger reductions in coffee output required destruction of coffee trees, the credit constraint caused the costs to increase more rapidly on those lower yielding farms which also had less operating capital per manzana.

When coffee tree removal was programmed as the means to reduce coffee output, highest costs were associated with the poorest farms. With the exceptions of the poorest farms, the costs of removing trees

that produced one fanega of coffee from production were below the costs of burning coffee after it had been produced. Generally, costs ranged upward from ¢14 per fanega and were clustered below ¢100. Reducing inputs to coffee, as a means of reducing output, can be expected to cost ¢75 to ¢125 per fanega when inputs are not reallocated to other uses.

Credit reductions sometimes reduced the production of other crops. When this occurred, credit reductions were an extremely expensive way of reducing coffee output. Costs ranged from ¢75 to over ¢2,000 per fanega of reduction in coffee output.

Blocking new plantings reduced optimal coffee output slightly on two farms. A tax or injunction against new plantings would not greatly reduce potential incomes with present price relationships.

Potential Effects of Technological Advances in Coffee Production

The major threat to the acceptance of a program of crop diversification is that technological changes in coffee production will be easier to initiate than more complex changes in farm management which shift resources out of coffee. Furthermore, given present prices, the returns to modernized coffee production surpass returns to alternatives that compete with coffee for the allocation of current resources on most farms. Many farms would double net incomes and expand coffee production if more productive coffee-growing activities could be employed. Even with prices or yields lowered 20 percent, the majority of the farms studied would increase net income by adopting new coffee technology. The increased coffee output expected from technological change would offset reductions expected from diversification of current

resources. The costs of reallocating resources to reduce coffee output will be increased by advances in coffee production technology.

The programmed incomes on seven out of eight farms with fruit or vegetable alternatives were higher when credit was increased than when coffee technology was changed. Therefore, if production of coffee is to be held in check by voluntary means, large increases in the supply of credit for horticultural crops must be made along with investments for processing plants and extension programs. Involuntary production controls using farm quotas is another way of checking the potential expansion.

The Qualifications of an Acceptable Alternative

In a study of this nature, all possible crops cannot be included because of time and cost restrictions. However, from the crops studied, certain patterns were indicated. An alternative must not higher returns per manzana than coffee if it is to cause coffee trees to be destroyed and the land planted to another crop. The difference must be high enough to pay for coffee tree removal.

Smaller downward adjustments in coffee production can occur when an alternative is superior to other non-coffee crops and competes with coffee for non-land resources. One may expect such changes to be temporary since over time increased income may allow purchases of additional inputs.

Before intensive, horticultural crops replace significant quantities of coffee, additional credit is required.

On most coffee farms, labor does not appear to be a critically limiting factor of production. Therefore, an acceptable alternative may use more hour-wage labor than coffee.

Finally, the alternative crop must face a stable price. Profit maximization is a rational alternative only after risk against loss is held to an acceptable level. Despite downward trends over the past few years, coffee prices in comparison with alternatives have been reasonably stable.

Diversification Versus Production Control

Crop diversification and coffee production control are not identical. Diversification can be rationally expanded in coffee growing regions. Diversification is a relative rather than an absolute concept. The benefits of risk reduction, income increases and tax-base expansion occur when the production of other crops is expanded whether or not coffee output is reduced. This analysis shows that some opportunity for crop diversification does exist. However, the projections of results of farm case studies to broader generalizations do not justify optimism that crop diversification can effectively control coffee output. Moreover, other factors influence decision making in addition to annual net income incentives. The higher level of risk and the need for closer supervision may block certain activities even when requirements for new technical knowledge are supplied.

Credit reduction can limit coffee production without aiding diversification and moderate credit expansion can aid diversification without limiting coffee output.

Profitable diversification alternatives lower the opportunity cost associated with involuntary reductions of coffee output. In comparison with the destruction of harvested coffee, the reallocation of resources to alternative uses is much cheaper as a means of controlling national

coffee sales. Likewise a program of quotas, payment for coffee tree removal, subsidies to alternative crops, or selective credit allocation probably would make diversification more acceptable to farmers.

GLOSSARY

1 bottle (botella)	= 1.5 pounds of milk	= 0.67 liters
1 colon	= \$0.1504 (official rate: \$1.00 = ₡6.65)	
1 fanega	= 540 to 560 pounds of coffee cherries or 104 pounds of coffee beans	= 400 liters
1 manzana	= 1.727 acres	= 0.698896 hectares
1 metric ton	= 2,204.6 pounds	= 1,000 kilograms
1 quintal	= 100 pounds (Spanish) or 101.4 pounds (English)	= 45 kilograms

APPENDIX

Introduction to the Appendix

The input and output coefficients used in this analysis are included in the Appendix. Changes in technology will undoubtedly alter yields and both quantity and quality of inputs used. The results and conclusions reached in this study will hold only as long as the yield and input coefficients are representative of existing relationships.

The following units of measure apply to the data in the appendix tables.

All labor, labor supervision and family harvest labor were recorded in hours.

The monetary unit is the colon ($\text{¢}6.65 = \$1.00$). The entries in the investment rows were made in units of 100 colones. The other monetary items are in units of one colon.

Land entries are in units of one manzana. Monthly entries were combined in the appendix tables with the first and last months designated.

Output coefficients varied from crop to crop. The most common unit, the quintal (100 Spanish pounds), was used for the following crops: corn, beans, sweetpotatoes, cassava, buckwheat, pigeon peas, chickpeas, limes, tobacco, strawberries and blackberries. Metric ton was used as the unit of production for sugarcane, tomatoes and peppers. Banana output was entered in units of 100 stems and orange output was entered in units of 100 fruits. Milk output was entered in units of 100 bottles (1.5 pounds each).

In a number of the appendix tables months of labor were omitted when no labor was required. Also, in order to conserve space, one or more digits to the right of the decimal, as used in the programming analyses, were omitted in the appendix tables.

Coefficients for coffee producing activities 1 through 5, Palmares-San Ramón

Item	Activity				
	1	2	3	4	5
Profit	-620.00	-633.55	-645.25	-553.05	-1,486.75
January labor	0	0	1.00	0	0
March labor	24.00	18.00	50.00	36.00	132.00
April labor	50.00	29.00	28.00	0	100.00
May labor	103.00	31.00	32.00	12.00	152.00
June labor	23.00	22.00	35.00	66.00	80.00
July labor	15.00	23.00	5.00	48.00	18.00
August labor	49.00	13.00	28.00	30.00	88.00
September labor	20.00	13.00	0	72.00	84.00
October labor	64.00	9.00	0	0	128.00
November labor	0	0	1.00	60.00	0
Investment	13.00 ^b	12.80 ^b	7.45 ^c	0	0
Operating capital	451.00	467.85	509.50	438.00	1,284.00
Rotation, castorbeans	1.00	1.00	1.00	1.00	1.00
Rotation, beans	1.00	1.00	1.00	1.00	1.00
Land, all year	1.00	1.00	1.00	1.00	1.00
Coffee land maximum	1.00	1.00	1.00	1.00	1.00
Coffee land minimum	1.00	1.00	1.00	1.00	1.00
Yield transfer	- 27.60 ^d	- 25.70 ^b	- 19.00	- 15.00	- 20.00
Yield change	27.60	25.70	19.00	15.00	20.00

^aThis activity was blocked on Farms 3 and 4.

^bThis entry of investment in hundreds of colones was not used on Farms 1 and 2 where the investment had already been made.

^cThis investment entry was used only for Farms 3 and 4.

^dIn this activity, yield was placed directly into the coffee transfer row only in Farms 1 and 2. Parametric programming procedures allowed this activity to be considered on Farms 3 through 8.

Coefficients for coffee producing activities 6 through 10, Palmares-San Ramon

Item	Activity				
	6 ^a	7	8	9	10
Profit	-482.40	-156.25	-770.00	-20.00	-375.00
January labor	0	0	0	0	0
February labor	0	0	0	0	0
March labor	36.00	60.00	132.00	0	60.00
April labor	20.00	60.00	15.00	20.00	30.00
May labor	37.00	75.00	0	0	18.00
June labor	12.00	75.00	48.00	0	6.00
July labor	31.00	35.00	36.00	0	0
August labor	12.00	50.00	24.00	45.00	16.00
September labor	0	50.00	36.00	45.00	30.00
October labor	7.00	0	0	0	0
November labor	0	0	0	0	0
December labor	0	0	0	0	0
Investment	0	0	0	0	0
Operating capital	405.00	103.00	664.00	0	322.70
Rotation, castorbeans	1.00	1.00	1.00	1.00	1.00
Rotation, beans	1.00	1.00	1.00	1.00	1.00
Land, all year	1.00	1.00	1.00	1.00	1.00
Coffee land maximum	1.00	1.00	1.00	1.00	1.00
Coffee land minimum	1.00	1.00	1.00	1.00	1.00
Yield transfer	- 15.00	- 9.00	- 15.00	- 4.00	- 5.30
Yield change	15.00	9.00	15.00	4.00	5.30

^aThis activity was blocked on Farms 3 and 4.

Coefficients for flue-cured tobacco producing activities, Palmares-San Ramón

Item	Activity		
	1	2	3
Profit	-2,617.70	-2,324.80	-2,785.70
Labor:			
January	377.00	200.00	125.00
February	59.00	277.00	0
March	0	120.00	0
June	30.00	0	0
July	260.00	0	180.00
August	115.00	248.00	69.00
September	230.00	118.00	153.00
October	159.00	30.00	93.00
November	315.00	0	22.00
December	510.00	0	137.00
Land:			
June-January	1.00	0	0
July-January	0	0	1.00
August-January	0	1.00	0
Investment	20.00	20.00	20.00
Operating capital	2,430.95	2,231.00	2,703.30
Flue-cured contract	1.00	1.00	1.00
Tobacco transfer, flue	- 20.00	- 17.60	- 18.80

Coefficients for burley tobacco producing activities, Palmares-San Ramón

Item	Activity		
	1	2	3
Profit	-1,447.10	-1,105.10	-1,293.70
January labor	675.00	146.00	300.00
February labor	20.00	0	0
July labor	33.00	0	0
August labor	254.00	180.00	180.00
September labor	194.00	127.00	123.00
October labor	412.00	79.00	183.00
November labor	209.00	192.00	126.00
December labor	462.00	146.00	108.00
Land, August through December	1.00	1.00	1.00
Operating capital	1,289.00	1,045.00	1,238.00
Burley contract	1.00	1.00	1.00
Tobacco transfer, burley	- 18.00	- 18.00	- 23.00

Coefficients of sun-cured tobacco producing activities, Palmares-San Ramón

Item	Activity		
	1	2	3
Profit	-1,031.40	-757.95	-1,028.80
Labor:			
January	0	210.00	0
February	589.0	200.00	210.00
March	68.00	0	
July	44.00	0	
August	172.00	0	204.00
September	153.00	126.00	59.00
October	196.00	72.00	137.00
November	57.00	168.00	98.00
December	320.00	0	186.00
Land:			
August-December	1.00	0	1.00
September-January	0	1.00	0
Operating capital	905.00	709.10	970.00
Sun-cured contract	1.00	1.00	1.00
Tobacco transfer, sun	- 19.00	- 19.00	- 20.00

Coefficients of corn producing activities 1 through 4, Palmares-San Ramón

Item	Activity			
	1	2	3	4
Profit	-484.50	-484.50	-352.15	-352.15
Labor:				
January	90.00	0	66.00	0
April	172.00	172.00	72.00	72.00
May	90.00	90.00	72.00	72.00
June	98.00	98.00	66.00	66.00
July	18.00	18.00	4.00	4.00
August	18.00	18.00	4.00	4.00
September	0	0	18.00	0
October	0	90.00	0	66.00
Land:				
April-January	1.00	0	0	0
April-October	0	1.00	0	1.00
March-January	0	0	1.00	0
Operating capital	351.40	351.40	259.40	259.40
Corn sheeling	- 69.00	- 70.00	- 48.00	- 49.00
Corn transfer	- 69.00	- 70.00	- 48.00	- 49.00
Special credit	-351.40	-351.40	-259.40	-259.40

Coefficients of corn producing activities 5 through 8, Palmares-San Ramón

Item	Activity			
	5	6	7	8
Profit	-156.50	-102.85	-142.95	-142.95
Labor:				
January	0	0	0	60.00
March	84.00	48.00	0	0
April	0	0	19.00	19.00
May	66.00	8.00	24.00	24.00
June	54.00	56.00	41.00	41.00
July	18.00	0	2.00	2.00
September	0	0	0	10.00
October	66.00	18.00	30.00	0
November	0	18.00	0	0
Land:				
March-October	1.00	0	0	0
March-November	0	1.00	0	0
April-July ^a	0	0	1.00	1.00
Operating capital	95.00	71.00	113.40	113.40
Corn shelling	- 40.00	- 24.00	- 13.00	- 13.00
Corn transfer	- 40.00	- 24.00	- 13.00	- 13.00
Special credit	- 95.00	- 71.00	-113.40	-113.40

^aThinly planted corn allows another crop to be planted after July.

Coefficients of corn-bean producing activities 1 through 4, Palmares-San Ramón

Item	Activity			
	1	2	3	4
Profit	-447.50	-251.95	-163.00	-162.10
Labor:				
January	54.00	0	0	60.00
March	0	84.00	0	48.00
April	72.00	0	19.00	0
May	72.00	102.00	0	56.00
June	66.00	86.00	53.00	68.00
July	4.00	18.00	2.00	12.00
August	4.00	66.00	72.00	72.00
September	18.00	44.00	66.00	66.00
October	152.00	60.00	20.00	20.00
November	60.00	0	20.00	20.00
December	0	0	0	20.00
Land:				
March-January	1.00	0	0	0
March-October	0	1.00	0	0
March-August ^a	0	0	1.00	0
April-August ^a	0	0	0	1.00
Operating capital	353.80	113.70	129.60	89.00
Rotation, beans	1.00	1.00	1.00	1.00
Corn shelling	- 48.00	- 40.00	- 13.00	- 24.00
Corn transfer	- 48.00	- 40.00	- 13.00	- 24.00
Bean transfer	- 9.60	- 4.00	- 5.40	- 5.40
Special credit	-353.80	-113.70	-129.60	- 89.00

^aAfter bean harvest the thinly planted corn allowed another crop to be planted.

Coefficients for bean producing activities 1 through 4, Palmares-San Ramón

Item	Activity			
	1	2	3	4
Profit	-396.95	-289.85	-116.10	- 62.10
Labor:				
January	57.00	0	60.00	60.00
February	0	0	0	28.00
April	0	280.00	0	0
May	0	90.00	0	0
June	0	98.00	0	0
July	0	57.00	0	0
August	240.00	18.00	0	0
September	92.00	47.00	0	0
October	51.00	108.00	80.00	22.00
November	12.00	0	60.00	0
December	47.00	0	0	0
Land:				
September-January	1.00	0	0	0
October-January	0	0	1.00	0
October-February	0	0	0	1.00
April-September	0	1.00	0	0
Operating capital	352.35	261.35	94.40	51.70
Rotation, beans	1.00	1.00	1.00	1.00
Bean transfer	- 20.00	- 18.00	- 9.50	- 4.20
Special credit	-352.35	-261.35	- 94.40	- 51.70

Coefficients for sesame and castorbean producing activities, Palmares-San Ramón

Item	Sesame		Castorbean	
	1	2	1	2
Profit	-267.90	-36.25	-450.85	-268.45
Labor:				
January	120.00	80.00	0	0
February	110.00	36.00	0	0
April	0	0	72.00	72.00
May	0	0	22.00	78.00
June	0	0	3.00	60.00
July	0	0	15.00	54.00
September	0	72.00	0	0
October	272.00	88.00	90.00	90.00
November	48.00	36.00	120.00	100.00
Land:				
September-January	0	1.00	0	0
October-January	1.00	0	0	0
April-October	0	0	1.00	1.00
Operating capital	228.75	19.00	370.25	203.70
Rotation, castorbean	0	0	5.00	5.00
Sesame transfer	- 20.00	-11.00	0	0
Castorbean transfer	0	0	- 34.00	- 32.00
Special credit	-228.75	-19.00	-370.25	-203.70

Coefficients for dairy activities, Palmares-San Ramón

Item	Activities				
	1	2	3	4	5
Profit	-476.9	-68.7	-63.0	-467.2	-188.2
Labor:					
January	20.0	15.0	15.0	10.0	10.0
February	20.0	15.0	15.0	10.0	10.0
March	20.0	15.0	15.0	10.0	10.0
April	20.0	15.0	15.0	10.0	10.0
May	20.0	15.0	15.0	10.0	10.0
June	27.0	15.0	15.0	17.0	17.0
July	24.0	29.0	35.0	10.0	10.0
August	24.0	29.0	35.0	14.0	14.0
September	24.0	15.0	35.0	10.0	10.0
October	24.0	15.0	15.0	10.0	10.0
November	20.0	15.0	15.0	10.0	10.0
December	20.0	15.0	15.0	10.0	10.0
Land	2.5	2.5	5.0	1.0	1.0
Operating capital ^a	2,286.9	608.7	603.0	1,277.2	977.2
Rotation, castorbeans	2.5	2.5	5.0	1.0	1.0
Rotation, beans	2.5	2.5	5.0	1.0	1.0
Investment	19.0	6.0	6.0	9.0	9.0
Milk transfer	- 30.0	-10.0	-10.0	- 20.0	- 10.0
Calf transfer	0	- 0.9	- 0.8	- 0.9	- 0.8
Special credit	-2,286.9	-608.7	-603.0	-1,277.2	-977.2

Coefficients for beef and pigeon pea and mixed crop producing activities, Palmares-San Ramón

Item	Beef		Pigeon pea	Mixed crop
	1	2		
Profit	-142.00	- 63.00	-308.90	-478.20
Labor:				
January	5.00	1.00	6.00	5.00
February	5.00	1.00	6.00	86.00
March	5.00	1.00	160.00	120.00
April	5.00	1.00	240.00	240.00
May	5.00	1.00	170.00	170.00
June	13.00	34.00	40.00	74.00
July	13.00	34.00	0	12.00
August	13.00	34.00	6.00	6.00
September	5.00	1.00	6.00	118.00
October	5.00	1.00	240.00	140.00
November	6.00	2.00	0	160.00
December	5.00	1.00	0	22.00
Land, all year	1.50	5.00	1.00	1.00
Operating capital	862.00	603.00	272.00	386.20
Investment	8.00	6.00	0	0
Rotation, castorbeans	1.50	5.00	0	0
Rotation, beans	1.50	5.00	1.00	1.00
Calf transfer	- 0.75	- 0.50	0	0
Pigeon pea transfer	0	0	- 20.00	- 13.00
Corn transfer	0	0	0	- 30.00
Bean transfer	0	0	0	- 4.80
Chickpea transfer	0	0	0	- 4.00
Special credit	-862.00	-603.00	-272.00	-386.00

Coefficients for peanut, chickpea and buckwheat producing activities,
Palmares-San Ramón

Item	Peanut	Chickpea	Buckwheat	
			1	2
Profit	-362.0	-82.6	-105.7	- 56.8
Labor:				
January	0	66.0	180.0	12.0
February	0	20.0	0	0
March	0	0	0	120.0
August	442.0	0	0	0
September	48.0	0	0	0
October	12.0	22.0	0	0
November	72.0	0	12.0	0
Land:				
August-November	1.0	0	0	0
October-February	0	1.0	0	0
November-January	0	0	1.0	0
January-March	0	0	0	1.0
Operating capital	312.0	77.2	72.5	40.4
Peanut transfer	- 20.0	0	0	0
Buckwheat transfer	0	0	- 20.0	- 8.0
Chickpea transfer	0	- 5.0	0	0
Special credit	-312.0	-77.2	- 72.5	-40.4

Coffee picking activities, all areas^a

Item	Coffee picking activity			
	January	February	November	December
Profit	1.0	1.0	1.0	1.0
Labor:				
January	1.0	0	0	0
February	0	1.0	0	0
November	0	0	1.0	0
December	0	0	0	1.0

^aAn additional picking activity for October coffee picking is included elsewhere for the Acosta area.

Coefficients for coffee harvesting and corn shelling operations,
Palmares-San Ramón

Item	Coffee harvesting		Corn shelling	
	Hired	Family	Hand labor	Contract
Profit	-40.00	0	0	-1.00
All labor:				
January	0.50	5.00	2.50	0
February	0.50	4.00	0	0
November	0.50	4.00	0	0
December	0.50	5.00	0	0
Family labor only:				
January	0	5.00	0	0
February	0	4.00	0	0
November	0	4.00	0	0
December	0	5.00	0	0
Coffee harvest	1.00	1.00	0	0
Corn shelling	0	0	1.00	1.00

Coefficients for borrowing, planting coffee, destroying coffee, and fixed costs transfer activities, all areas

Item	Activities			
	Borrow	Plant coffee	Destroy coffee	Transfer fixed costs
Profit	-6.0	- 300.0	- 60.0	-100.0
Investment	-1.0	104.0	6.0	0
Interest change	-1.0	0	0	0
Operating capital	0	2,108.4	600.0	0
Coffee land maximum	0	- 1.0	1.0	0
Coffee land minimum	0	0	- 1.0	0
Existing coffee	0	0	1.0	0
Removal payment	0	-9,999.0	1.0	0
Fixed expenditures	0	0	0	1.0

Coefficients for moving family workers and permanent employees to off-farm employment, all areas

Item	Labor movement activities	
	Family	Employees
All labor:		
January	156.0	156.0
February	144.0	144.0
March	162.0	162.0
April	150.0	150.0
May	162.0	162.0
June	156.0	156.0
July	162.0	162.0
August	150.0	150.0
September	150.0	150.0
October	162.0	162.0
November	150.0	150.0
December	120.0	120.0
Family labor:		
January	156.0	0
February	144.0	0
November	150.0	0
December	120.0	0
Supervision:		
January	312.0	312.0
February	288.0	288.0
March	324.0	324.0
April	300.0	300.0
May	324.0	324.0
June	312.0	312.0
July	324.0	324.0
August	300.0	300.0
September	300.0	300.0
October	324.0	324.0
November	300.0	300.0
December	240.0	240.0
Family men	1.0	0
Men employed	0	1.0
Off-farm pay	3,116.0	0
Reduced labor ^a	0	2,208.0
Reduced labor cost (Acosta)	0	1,520.0

^a All other areas except Acosta.

Coefficients of right-hand-side constraints, farms 1 through 4,
Palmares-San Ramón

Item	Farms			
	1	2	3	4
Labor:				
January	936.00	1,560.0	1,404.0	1,560.0
February	864.0	1,440.0	1,296.0	1,440.0
March	580.0	1,390.0	1,458.0	1,066.0
April	540.0	1,290.0	1,350.0	1,990.0
May	580.0	1,390.0	1,458.0	1,066.0
June	560.0	1,340.0	1,404.0	1,058.0
July	580.0	1,390.0	1,458.0	1,066.0
August	540.0	1,290.0	1,350.0	990.0
September	540.0	1,290.0	1,350.0	990.0
October	580.0	1,390.0	1,458.0	1,066.0
November	735.0	1,390.0	1,350.0	1,360.0
December	720.0	1,200.0	1,080.0	1,200.0
Land, each month	5.0	7.0	56.0	20.0
Operating capital	4,400.0	4,000.0	71,100.0	16,900.0
Burley contract	2.0	0	0	0
Flue-cured contract	0	0	3.0	5.0
Rotation, castorbeans	5.0	7.0	56.0	20.0
Rotation, beans	5.0	7.0	56.0	20.0
Harvest labor:				
January	624.0	624.0	0	1,348.0
February	576.0	576.0	0	1,252.0
November	435.0	390.0	0	1,090.0
December	480.0	480.0	0	960.0
Supervision:				
January	624.0	2,184.0	4,680.0	1,560.0
February	576.0	2,016.0	4,320.0	1,440.0
March	648.0	2,268.0	4,860.0	1,620.0
April	600.0	2,100.0	4,500.0	1,500.0
May	648.0	2,268.0	4,860.0	1,620.0
June	624.0	2,184.0	4,680.0	1,560.0
July	648.0	2,268.0	4,860.0	1,620.0
August	600.0	2,100.0	4,500.0	1,500.0
September	600.0	2,100.0	4,500.0	1,500.0
October	648.0	2,268.0	4,860.0	1,620.0
November	600.0	2,100.0	4,500.0	1,500.0
December	480.0	1,680.0	3,600.0	1,200.0
Fixed expenditures	61.8	166.9	601.0	148.4
Coffee land maximum	3.0	7.0	50.0	15.0
Coffee land minimum	3.0	7.0	50.0	15.0
Existing coffee	3.0	7.0	50.0	15.0
Family men	1.0	2.0	0	3.0
Men employed	2.0	5.0	9.0	3.0
Allotment of quota	62.2	135.0	562.5	168.7

Coefficients of right-hand-side constraints, farms 5 through 8,
Palmares-San Ramón

Item	Farms			
	5	6	7	8
Labor:				
January	624.0	624.0	312.0	624.0
February	576.0	576.0	288.0	576.0
March	648.0	648.0	162.0	418.0
April	600.0	600.0	150.0	390.0
May	648.0	648.0	162.0	418.0
June	624.0	624.0	156.0	404.0
July	648.0	648.0	162.0	418.0
August	600.0	600.0	150.0	390.0
September	600.0	600.0	150.0	390.0
October	648.0	648.0	162.0	418.0
November	600.0	600.0	300.0	490.0
December	480.0	480.0	240.0	480.0
Land	10.0	4.0	6.0	2.0
Operating capital	6,400.0	4,000.0	4,300.0	900.0
Sun-cured contract	0	0	1.0	0.5
Rotation, castorbeans	10.0	4.0	6.0	2.0
Rotation, beans	10.0	4.0	6.0	2.0
Harvest labor:				
January	312.0	0	156.0	624.0
February	288.0	0	144.0	576.0
November	300.0	0	150.0	340.0
December	240.0	0	120.0	360.0
Supervision:				
January	1,248.0	1,248.0	624.0	624.0
February	1,152.0	1,152.0	576.0	576.0
March	1,296.0	1,296.0	324.0	648.0
April	1,200.0	1,200.0	300.0	600.0
May	1,296.0	1,296.0	324.0	648.0
June	1,248.0	1,248.0	312.0	624.0
July	1,296.0	1,296.0	324.0	648.0
August	1,200.0	1,200.0	300.0	600.0
September	1,200.0	1,200.0	300.0	600.0
October	1,296.0	1,296.0	324.0	648.0
November	1,200.0	1,200.0	600.0	600.0
December	960.0	960.0	480.0	480.0
Fixed expenditures	107.3	124.8	60.0	28.8
Coffee land maximum	10.0	3.7	3.0	1.0
Coffee land minimum	10.0	3.7	3.0	1.0
Existing coffee	10.0	3.7	3.0	1.0
Family men	2.0	0	0	1.0
Men employed	2.0	4.0	1.0	1.0
Allotment of quota	142.5	53.4	42.7	11.2

Coefficients for coffee producing activities 1 through 9, Alajuela

Item	Activity								
	1	2	3	4	5	6	7	8	9
Profit	-547.9	-1,290.1	-682.6	-599.0	-550.1	-627.5	-358.0	-156.2	-20.0
Labor:									
January	20.0	48.0	0	40.0	20.0	0	0	0	0
February	20.0	48.0	0	12.0	0	39.0	0	0	0
March	0	21.0	60.0	0	30.0	30.0	48.0	60.0	0
April	16.0	6.0	0	8.0	0	0	16.0	60.0	20.0
May	36.0	21.0	57.0	47.0	112.0	88.0	48.0	75.0	0
June	96.0	50.0	34.0	49.0	36.0	36.0	24.0	75.0	0
July	96.0	37.0	109.0	65.0	18.0	18.0	64.0	35.0	0
August	22.0	74.0	34.0	5.0	0	0	64.0	50.0	45.0
September	64.0	0	60.0	89.0	0	4.0	0	50.0	45.0
October	48.0	0	0	0	0	6.0	48.0	0	0
November	0	11.0	0	8.0	20.0	0	0	0	0
Land, all year	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Operating capital	414.8	1,095.7	539.5	481.5	457.5	512.5	276.5	103.0	0
Investment ^a	12.8	13.4	12.8	0	0	0	0	0	0
Coffee land maximum	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Coffee land minimum	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Rotation:									
Strawberries	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Beans	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Cucurbits	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Tomatoes	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Coffee transfer	- 25.0 ^b	- 25.0 ^b	- 25.0 ^b	- 20.0	- 14.0	- 16.0	- 15.0	- 9.0	- 4.0
Yield change	25.0	25.0	25.0	20.0	14.0	16.0	15.0	9.0	4.0

^a Investment entries were excluded from the coffee activities for Farm 9 which already had made the intensification investments.

^b Yields for best yielding activities were placed directly into the coffee transfer row only for Farm 9. Parametric changes allowed them to be considered for Farms 10, 11 and 12.

Coefficients for citrus, strawberry and pineapple producing activities,
Alajuela

Item	Activity			
	Limes	Oranges	Straw- berries	Pine- apples
Profit	-1,767.6	-2,019.6	-12,817.2	-5,853.0
Labor:				
January	55.0	54.0	450.0	90.0
February	10.0	54.0	450.0	90.0
March	10.0	14.0	450.0	450.0
April	10.0	14.0	450.0	384.0
May	55.0	54.0	195.0	439.0
June	55.0	54.0	195.0	234.0
July	71.0	62.0	195.0	372.0
August	71.0	54.0	225.0	324.0
September	58.0	54.0	425.0	258.0
October	10.0	14.0	395.0	228.0
November	10.0	14.0	500.0	0
December	10.0	14.0	401.0	0
Land:				
All year	1.0	1.0	0	4.0
June-August	0	0	1.0	0
September-May	0	0	2.0	0
Investment	150.0	162.0	0	0
Operating capital	450.0	249.0	6,090.0	4,462.5
Line transfer	- 400.0	0	0	0
Orange transfer	0	1,020.0	0	0
Strawberry transfer	0	0	- 250.0	0
Pineapple transfer	0	0	0	- 78.0
Rotation, strawberries	1.0	1.0	10.0	0
Rotation, beans	1.0	1.0	0	0
Rotation, cucurbits	1.0	1.0	0	0
Rotation, tomatoes	1.0	1.0	0	0
Special credit	- 450.0	- 249.0	-6,090.0	-4,462.5

Coefficients for corn producing activities, Alajuela

Item	Activity		
	1	2	3
Profit	-449.5	-715.0	-251.9
Labor:			
January	0	0	74.0
February	0	0	24.0
March	0	0	36.0
April	272.0	4.0	0
May	90.0	90.0	41.0
June	98.0	98.0	41.0
July	18.0	18.0	58.0
August	18.0	18.0	72.0
September	0	0	0
October	90.0	90.0	0
November	0	0	0
December	0	0	0
Land:			
April-October	1.0	1.0	0
All year	0	0	1.0
Operating capital	351.4	551.4	149.9
Corn transfer	- 80.0	- 90.0	- 60.0
Special credit	-351.4	-551.4	-149.9
Yield increase	- 1.0	- 1.0	0

Coefficients for bean producing activities, Alajuela

Item	Activity		
	1	2	3
Profit	-521.0	-60.8	-139.1
Labor:			
January	0	28.0	48.0
April	4.0	0	0
May	2.0	0	0
June	92.0	0	0
July	51.0	0	0
August	65.0	0	0
September	51.0	22.0	72.0
October	0	0	0
December	0	60.0	72.0
Land:			
April-September	1.0	0	0
September-December	0	1.0	1.0
Operating capital	455.2	51.7	122.0
Rotation, beans	1.0	1.0	1.0
Bean transfer	- 20.0	- 5.0	- 10.0
Special credit	-455.2	-51.7	-122.0

Coefficients for corn and bean, and peanut producing activities,
Alajuela

Item	Corn-bean		Peanut
	1	2	
Profit	-1,046.1	-78.0	-362.0
Labor:			
March	4.0	72.0	0
April	28.0	0	0
May	65.0	2.0	0
June	29.0	60.0	0
July	48.0	51.0	0
August	0	40.0	442.0
September	94.0	34.0	48.0
October	48.0	44.0	12.0
November	55.0	0	72.0
December	51.0	0	0
Land:			
March-December	1.0	0	0
March-October	0	1.0	0
August-November	0	0	1.0
Operating capital	877.0	42.0	312.0
Corn transfer	- 48.0	-20.0	0
Bean transfer	- 18.0	- 4.0	0
Peanut transfer	0	0	- 20.0

Coefficients for sugarcane producing activities 1 through 6, Alajuela

Item	Activity ^a					
	1	2	3	4	5	6
Profit	-1,999.2	-2,000.0	-3,467.5	-3,468.0	-3,100.1	-3,101.0
Labor:						
January	352.0	352.0	1,112.0	0	324.0	0
February	352.0	352.0	1,112.0	0	376.0	324.0
March	300.0	300.0	114.0	1,112.0	376.0	324.0
April	296.0	296.0	0	1,112.0	72.0	376.0
May	0	0	0	144.0	72.0	376.0
June	252.0	252.0	0	0	0	72.0
July	148.0	252.0	0	0	0	72.0
August	216.0	48.0	0	0	128.0	0
September	84.0	352.0	204.0	0	128.0	128.0
October	0	0	0	204.0	0	128.0
December	400.0	48.0	0	0	324.0	0
Land:						
All year	4.0	4.0	3.0	3.0	3.0	3.0
January-April	0	0	0	1.0	0	0
February-March	0	0	0	0	4.0	0
April-May	0	0	0	0	0	4.0
November-February	0	0	1.0	0	0	0
Operating capital	1,520.0	1,520.0	2,296.2	2,296.2	2,133.0	2,133.0
Sugarcane transfer	- 180.0	- 180.0	- 300.0	- 300.0	- 240.0	- 240.0

^apairs of activities were derived from the same budgets to allow the work load to be spread over different time periods.

Coefficients for sweetpotato and cassava producing activities, Alajuela

Item	Sweetpotato		Cassava		
	1	2	1	2	3
Profit	-1,262.45	-346.25	-669.80	-1,277.75	-1,029.00
Labor:					
February	0	334.00	0	0	0
April	192.00	0	120.00	0	0
May	116.00	0	0	80.00	80.00
June	104.00	0	0	0	198.00
July	28.00	0	102.00	0	0
August	438.00	0	0	180.00	56.00
September	0	0	128.00	60.00	0
October	0	384.00	0	0	80.00
November	0	96.00	85.00	85.00	0
December	0	24.00	0	0	0
Land:					
All year	0	0	1.00	2.00	2.00
April-August	1.00	0	0	0	0
October-February	0	1.00	0	0	0
August-April	0	0	1.00	0	0
May-June	0	0	0	0	1.00
Operating capital	891.15	228.00	200.00	1,772.00	1,300.00
Cassava transfer	0	0	-150.00	-200.00	-275.00
Sweetpotato transfer	-300.00	-100.00	0	0	0
Special credit	-891.15	-228.00	-200.00	-1,772.00	-1,300.00

Coefficients for buckwheat and chickpea producing activities, Alajuela

Item	Buckwheat	Chickpea
Profit	-56.7	-82.0
Labor:		
January	12.0	66.0
February	0	20.0
March	120.0	0
October	0	22.0
Land:		
January-March	1.0	0
October-February	0	1.0
Operating capital	40.4	77.2
Buckwheat transfer	- 8.0	0
Chickpea transfer	0	- 5.0
Special credit	-40.4	-77.2

Coefficients for cucumber and tomato producing activities, Alajuela

Item	Cucumber		Tomato	
	1	2	1	2
Profit	-1,601.2	-1,602.0	-2,545.0	-2,454.0
Labor:				
January	0	350.0	592.0	0
February	0	157.0	592.0	0
March	325.0	825.0	0	0
April	157.0	0	0	0
May	825.0	0	0	102.0
June	0	0	0	522.0
July	0	0	0	288.0
August	0	0	0	279.0
September	0	0	168.0	138.0
October	0	0	208.0	378.0
November	0	0	390.0	120.0
December	0	0	374.0	0
Land:				
March-May	1.0	0	0	0
January-March	0	1.0	0	0
May-October	0	0	0	1.0
September-February	0	0	1.0	0
Operating capital	1,499.2	1,499.2	1,744.0	1,655.0
Rotation, tomatoes	0	0	2.0	2.0
Rotation, cucurbits	4.0	4.0	0	0
Cucumber transfer	140.0	140.0	0	0
Tomato transfer	0	0	- 27.7	- 11.2
Special credit	-1,499.2	-1,499.2	-1,744.0	-1,655.0

Coefficients for sweet pepper, dairy, and pigeon pea producing activities, Alajuela

Item	Pepper		Dairy	Pigeon pea
	1	2		
Profits	-1,937.8	-1,243.0	- 467.2	-308.9
Labor:				
January	189.0	196.0	10.0	6.0
February	189.0	156.0	10.0	6.0
March	189.0	156.0	10.0	160.0
April	189.0	156.0	10.0	240.0
May	0	0	10.0	170.0
June	0	0	17.0	40.0
July	0	102.0	10.0	0
August	150.0	60.0	14.0	6.0
September	174.0	60.0	10.0	6.0
October	168.0	0	10.0	240.0
November	168.0	100.0	10.0	0
December	92.0	70.0	10.0	0
Land:				
All year	0	0	1.0	1.0
July-April	0	1.0	0	0
August-April	1.0	0	0	0
Investment	0	0	9.0	0
Operating capital	1,298.0	920.0	1,277.2	272.0
Rotation, strawberries	0	0	1.0	0
Rotation, beans	0	0	1.0	1.0
Rotation, cucurbits	0	0	1.0	0
Rotation, tomatoes	2.0	2.0	1.0	0
Pepper transfer	- 9.0	- 7.5	0	0
Milk transfer	0	0	- 20.0	0
Calf transfer	0	0	- 0.9	0
Pigeon pea transfer	0	0	0	- 20.0
Special credit	-1,298.0	- 920.0	-1,277.2	-272.0

Coefficients for coffee, grain and dairy selling activities, Alajuela

Item	Coffee			Corn	Beans	Buck- wheat	Pigeon Pea	Chick- pea	Sugar- cane	Milk	Calves
	1	2	3								
Profit	196.73	157.38	0	22.0	70.0	15.0	60.0	90.0	50.0	60.0	200.0
Coffee harvest	- 1.0	- 1.0	- 1.0	0	0	0	0	0	0	0	0
Coffee transfer	1.0	1.0	0	0	0	0	0	0	0	0	0
Price decline	- 1.0	- 1.0	0	0	0	0	0	0	0	0	0
Two prices	-196.73	0	209.85	0	0	0	0	0	0	0	0
Allotment	0	0	0	0	0	0	0	0	0	0	0
Corn transfer	0	0	0	1.0	0	0	0	0	0	0	0
Bean transfer	0	0	0	0	1.0	0	0	0	0	0	0
Buckwheat transfer	0	0	0	0	0	1.0	0	0	0	0	0
Pigeon pea transfer	0	0	0	0	0	0	1.0	0	0	0	0
Chickpea transfer	0	0	0	0	0	0	0	1.0	0	0	0
Sugarcane transfer	0	0	0	0	0	0	0	0	1.0	0	0
Milk transfer	0	0	0	0	0	0	0	0	0	1.0	0
Calf transfer	0	0	0	0	0	0	0	0	0	0	1.0
Traditional crops only	0	0	0	0	0	-15.0	-60.0	-90.0	0	0	0

Coefficients for fruit and vegetable selling activities, Alajuela

Item	Lime	Oranges	Straw- berries	Pine- apples	Peppers	Tomatoes	Cucum- bers	Sweet- potato	Cassava
Profit	13.0	4.0	100.0	140.0	700.0	300.0	25.0	15.0	7.0
Lime transfer	1.0	0	0	0	0	0	0	0	0
Lime price increase	1.0	0	0	0	0	0	0	0	0
Lime price decrease	-1.0	0	0	0	0	0	0	0	0
Orange transfer	0	1.0	0	0	0	0	0	0	0
Orange price increase	0	1.0	0	0	0	0	0	0	0
Orange price decrease	0	-1.0	0	0	0	0	0	0	0
Strawberry transfer	0	0	1.0	0	0	0	0	0	0
Strawberry price increase	0	0	1.0	0	0	0	0	0	0
Strawberry price decrease	0	0	-1.0	0	0	0	0	0	0
Pineapple transfer	0	0	0	1.0	0	0	0	0	0
Pineapple price increase	0	0	0	1.0	0	0	0	0	0
Pepper transfer	0	0	0	0	1.0	0	0	0	0
Tomato transfer	0	0	0	0	0	1.0	0	0	0
Cucumber transfer	0	0	0	0	0	0	1.0	0	0
Sweetpotato trans- fer	0	0	0	0	0	0	0	1.0	0
Cassava transfer	0	0	0	0	0	0	0	0	1.0
Traditional crops only	-13.0	-4.0	-100.0	-140.0	-700.0	-300.0	-25.0	-15.0	-7.0
Cheaper vegeta- bles	0	0	0	0	-700.0	-300.0	-25.0	-15.0	-7.0

Coffee harvesting activities, Alajuela

Item	Family	Hired
Profit	0	-40.0
Labor:		
January	5.0	0.5
February	4.0	0.5
November	4.0	0.5
December	5.0	0.5
Harvest labor:		
January	5.0	0
February	4.0	0
November	4.0	0
December	5.0	0
Coffee harvest	1.0	1.0

Coefficients of right hand side constraints for Alajuela farms

Item	Farms			
	9	10	11	12
Labor:				
January	2,184.0	1,248.0	936.0	1,716.0
February	2,016.0	1,152.0	834.0	1,584.0
March	2,025.0	1,174.0	486.0	1,296.0
April	1,875.0	1,131.0	450.0	1,200.0
May	2,025.0	1,174.0	486.0	1,296.0
June	1,950.0	1,131.0	468.0	1,248.0
July	2,025.0	1,174.0	486.0	1,296.0
August	1,875.0	1,087.0	450.0	1,200.0
September	1,875.0	1,087.0	450.0	1,200.0
October	2,025.0	1,174.0	486.0	1,296.0
November	1,950.0	1,125.0	750.0	1,650.0
December	1,680.0	960.0	720.0	1,320.0
Land	40.0	15.0	10.5	5.5
Operating capital	22,200.0	15,750.0	8,850.0	1,115.0
Harvest labor, family:				
January	624.0	468.0	780.0	1,404.0
February	576.0	432.0	720.0	1,296.0
November	450.0	375.0	600.0	1,350.0
December	480.0	360.0	600.0	1,080.0
Supervision of labor:				
January	3,744.0	2,184.0	624.0	1,560.0
February	3,456.0	2,016.0	576.0	1,440.0
March	3,888.0	2,268.0	648.0	1,620.0
April	3,600.0	2,100.0	600.0	1,500.0
May	3,888.0	2,268.0	648.0	1,620.0
June	3,744.0	2,184.0	624.0	1,560.0
July	3,888.0	2,268.0	648.0	1,620.0
August	3,600.0	2,100.0	600.0	1,500.0
September	3,600.0	2,100.0	600.0	1,500.0
October	3,888.0	2,268.0	648.0	1,620.0
November	3,600.0	2,100.0	600.0	1,500.0
December	2,880.0	1,680.0	480.0	1,200.0
Rotation, strawberries	40.0	15.0	10.5	5.5
Rotation, beans	40.0	15.0	10.5	5.5
Rotation, cucurbits	40.0	15.0	10.5	5.5
Rotation, tomatoes	40.0	15.0	10.5	5.5
Fixed expenditures	485.7	218.7	96.7	79.0
Coffee land maximum	40.0	15.0	5.0	2.5
Coffee land minimum	40.0	15.0	5.0	2.5
Existing coffee	40.0	15.0	5.0	2.5
Family men	2.0	2.0	1.0	3.0
Men employed	10.0	5.0	1.0	2.0
Allotment	750.0	225.0	75.0	16.7

Coefficients of coffee producing activities 1 through 4, Acosta

Item	Activity ^a			
	1	2	3	4
Profit	-677.00	-676.35	-490.00	-489.40
Labor:				
January	16.00	31.00	40.00	40.00
February	15.00	68.00	10.00	10.00
March	68.00	71.00	32.00	32.00
April	51.00	18.00	23.00	13.00
May	38.00	18.00	21.00	31.00
June	18.00	18.00	14.00	14.00
July	56.00	73.00	57.00	114.00
August	47.00	30.00	72.00	72.00
September	32.00	16.00	57.00	0
October	0	16.00	40.00	40.00
Investment	12.80	12.80	0	0
Operating capital	547.75	547.75	315.20	315.20
Land, all year	1.00	1.00	1.00	1.00
Coffee land maximum	1.00	1.00	1.00	1.00
Coffee land minimum	1.00	1.00	1.00	1.00
Coffee transfer	0	0	- 10.00	- 10.00
Yield potential	- 14.00	- 14.00	0	0
Yield change	0	0	10.00	10.00

^aTwo activities were derived from each budget to allow flexibility in work scheduling.

Coefficients for coffee producing activities 5 through 7, Acosta

Item	Activity		
	5	6	7
Profit	-155.3	-156.0	-15.0
Labor:			
March	40.0	40.0	0
April	60.0	80.0	0
May	64.0	44.0	0
July	50.0	120.0	0
August	70.0	0	0
September	0	0	80.0
October	100.0	100.0	0
Operating capital	116.0	116.0	0
Land:			
All year	1.0	1.0	1.0
Coffee land maximum	1.0	1.0	1.0
Coffee land minimum	1.0	1.0	1.0
Coffee transfer	- 6.0	- 6.0	- 2.0
Yield change	6.0	6.0	2.0

Coefficients for coffee-fruit producing activities, Acosta

Item	Activity	
	Coffee-orange- banana	Coffee-orange
Profit	-459.2	-300.0
Labor:		
January	90.0	30.0
February	90.0	30.0
March	90.0	40.0
April	70.0	20.0
May	40.0	112.0
June	10.0	0
July	60.0	0
August	0	120.0
October	15.0	100.0
December	120.0	20.0
Land	1.0	1.0
Coffee land maximum	1.0	1.0
Coffee land minimum	1.0	1.0
Coffee transfer	- 5.0	- 6.0
Orange transfer	- 10.0	- 30.0
Banana transfer	- 1.0	- 0.5
Yield change (coffee)	5.0	6.0

Coefficients for fruit producing activities, Acosta

Item	Activity			
	Orange 1	Orange 2	Limes	Black-berries
Profit	-2,019.6	-1,432.1	-1,767.6	-8,578.7
Labor:				
January	54.0	36.0	55.0	340.0
February	54.0	36.0	55.0	280.0
March	14.0	0	10.0	280.0
April	14.0	0	10.0	180.0
May	54.0	36.0	55.0	140.0
June	54.0	36.0	55.0	180.0
July	62.0	32.0	71.0	180.0
August	54.0	32.0	71.0	140.0
September	54.0	32.0	58.0	80.0
October	14.0	0	10.0	80.0
November	14.0	0	10.0	140.0
December	14.0	0	10.0	80.0
Investment	162.5	58.2	150.0	0
Operating capital	249.0	155.0	450.0	3,684.0
Land	1.0	1.0	1.0	1.0
Orange transfer	-1,020.0	- 533.3	0	0
Lime transfer	0	0	- 400.0	0
Blackberry transfer	0	0	0	- 160.0
Special credit	- 249.0	- 155.0	- 450.0	-3,684.0

Coefficients for corn-bean producing activities, Acosta

Item	Activity		
	1	2	3
Profit	-438.4	-117.7	-185.5
Labor:			
April	12.0	20.0	10.0
May	36.0	24.0	50.0
June	24.0	20.0	0
August	0	40.0	0
September	54.0	48.0	60.0
October	21.0	0	0
December	0	160.0	74.0
Land	1.0	1.0	1.0
Operating capital	318.0	86.0	135.0
Corn transfer	- 29.0	- 6.4	- 16.0
Bean transfer	- 11.0	- 9.6	- 6.6
Special credit	-318.0	- 86.0	-135.0

Coefficients for dairy producing activities, Acosta

Item	Activity				
	1	2	3	4	5
Profit	-476.9	- 68.7	- 63.0	-467.2	-188.2
Labor:					
January	20.0	15.0	15.0	10.0	10.0
February	20.0	15.0	15.0	10.0	10.0
March	20.0	15.0	15.0	10.0	10.0
April	20.0	15.0	15.0	10.0	10.0
May	20.0	15.0	15.0	10.0	10.0
June	27.0	15.0	15.0	17.0	17.0
July	24.0	29.0	35.0	10.0	10.0
August	24.0	29.0	35.0	14.0	14.0
September	24.0	15.0	35.0	10.0	10.0
October	24.0	15.0	15.0	10.0	10.0
November	20.0	15.0	15.0	10.0	10.0
December	20.0	15.0	15.0	10.0	10.0
Land	2.5	2.5	5.0	1.0	1.0
Operating capital	2,289.9	608.7	603.0	1,277.2	977.2
Investment	19.0	6.0	6.0	9.0	9.0
Milk transfer	- 30.0	- 10.0	- 10.0	- 20.0	- 10.0
Calf transfer	0	0.9	0.8	0.9	- 80.0
Special credit	-2,289.9	-608.7	-603.0	-1,277.2	-977.2

Coefficients for beef producing activities, Acosta

Item	Activity	
	1	2
Profit	-142.0	- 63.0
Labor:		
January	5.0	1.0
February	5.0	1.0
March	5.0	1.0
April	5.0	1.0
May	5.0	1.0
June	13.0	1.0
July	13.0	34.0
August	13.0	34.0
September	5.0	1.0
October	5.0	1.0
November	6.0	1.0
December	5.0	1.0
Land	1.5	5.0
Investment	8.0	6.0
Operating capital	862.0	603.0
Calf transfer	- 0.7	- 0.5
Special credit	-862.0	-603.0

Coefficients for coffee, corn, bean, calf and milk selling activities, Acosta

Item	Activity					
	Averaged coffee	New coffee	Traditional coffee	Corn	Beans	Milk Calf
Profit	215.2	172.3	0	22.0	70.0	60.0 200.0
Coffee harvest	- 1.0	- 1.0	- 1.0	0	0	0 0
Coffee transfer	1.0	1.0	1.0	0	0	0 0
Allotment	0	0	0	0	0	0 0
Two prices	-215.2	0	233.1	0	0	0 0
Price decline, coffee	- 1.0	- 1.0	0	0	0	0 0
Corn transfer	0	0	0	1.0	0	0 0
Bean transfer	0	0	0	0	1.0	0 0
Milk transfer	0	0	0	0	0	1.0 0
Calf transfer	0	0	0	0	0	0 1.0

Coefficients for fruit selling activities, Acosta

Item	Activity			
	Bananas	Limes	Oranges	Blackberries
Profit, low fruit prices ^a	100.0	9.0	3.0	50.0
Profit, high fruit prices ^a	100.0	3.0	4.0	100.0
Labor, each month ^b	4.0	0	0	0
Lime transfer	0	1.0	0	0
Lime price increase	0	1.0	0	0
Lime price decrease	0	-1.0	0	0
Orange transfer	0	0	1.0	0
Orange price increase	0	0	1.0	0
Orange price decrease	0	0	-1.0	0
Blackberry transfer	0	0	0	1.0
Blackberry price increase	0	0	0	1.0
Blackberry price decrease	0	0	0	-1.0
Banana transfer	1.0	0	0	0

^aProblems were first solved using low fruit prices, then solved using high fruit prices.

^bSince bananas were primarily grown for shade, harvest was optional and included as part of the selling activity.

Coefficients for coffee harvesting activities, Acosta

Item	Harvesting		October ^a picking
	Hired	Family	
Profit	-40.0	0	1.0
Labor:			
January	0.5	5.0	0
February	0.5	4.0	0
October	0.5	4.0	1.0
November	0.5	4.0	0
December	0.5	5.0	0
Family harvest labor:			
January	0	5.0	0
February	0	4.0	0
October	0	4.0	0
November	0	4.0	0
December	0	5.0	0

^aThe harvest season began one month earlier in Acosta than in the other two areas; therefore, unused farm labor could be sold in October as well as in the period from November through February included in the transfer activities common to all area matrices.

Coefficients of right hand side constraints for farms 13-16, Acosta

Item	Farms			
	13	14	15	16
Labor:				
January	2,808.0	468.0	624.0	624.0
February	2,592.0	432.0	576.0	576.0
March	2,835.0	486.0	405.0	468.0
April	2,625.0	450.0	375.0	450.0
May	2,835.0	486.0	405.0	486.0
June	2,730.0	468.0	385.0	468.0
July	2,835.0	486.0	405.0	486.0
August	2,625.0	450.0	375.0	450.0
September	2,625.0	450.0	375.0	450.0
October	2,916.0	486.0	648.0	648.0
November	2,700.0	450.0	600.0	600.0
December	2,100.0	360.0	480.0	480.0
Operating capital	51,422.7	5,945.0	825.0	675.0
Land	101.5	16.0	2.0	6.5
Harvest labor, family:				
January	624.0	468.0	624.0	312.0
February	576.0	432.0	576.0	288.0
October	648.0	486.0	648.0	324.0
November	600.0	450.0	600.0	300.0
December	480.0	360.0	480.0	240.0
Supervision of labor:				
January	5,304.0	936.0	312.0	624.0
February	4,896.0	864.0	288.0	576.0
March	5,508.0	472.0	324.0	648.0
April	5,100.0	900.0	300.0	600.0
May	5,508.0	972.0	324.0	648.0
June	5,304.0	936.0	312.0	624.0
July	5,508.0	972.0	324.0	648.0
August	5,100.0	900.0	300.0	600.0
September	5,100.0	900.0	300.0	600.0
October	5,508.0	972.0	324.0	648.0
November	5,100.0	900.0	300.0	600.0
December	4,080.0	720.0	240.0	480.0
Fixed expenditures	475.0	11.5	4.2	29.9
Family men	4.0	3.0	1.0	1.0
Men employed	9.0	0.0	0.0	1.0
Coffee land maximum	90.0	7.0	2.0	1.5
Coffee land minimum	90.0	7.0	2.0	1.5
Existing coffee	90.0	7.0	2.0	1.5
Allotment	675.0	52.5	7.5	5.6

LITERATURE CITED

1. Abercrombie, K. C. "Population Growth and Agricultural Development." Monthly Bulletin of Agricultural Economics and Statistics, 18 (4): 1-8. April, 1967.
2. Acosta, Rogelio and Rodrigo Cleves. Tipos de Café de Costa Rica. Boletín Técnico No. 1, Oficina del Café. San José, Costa Rica: 1964.
3. Allegor, Daniel E. "Agricultural Economics," pp. 26-50. Fertile Lands of Friendship, ed. D. Allegor. Gainesville, Florida: The University of Florida Press, 1962.
4. Anker Ladefoged, A. V. "Cultivation of Buckwheat on Up-Country Patanas." Tropical Agriculturist, 108 (4): 269-270. 1952.
5. Armijo Pujoi, Alberto. Estudios de Evaluación. Rendimiento Total, Comercial, No Comercial y Follaje de Variedades de Camote (Ipomoea batatas L.) Influencias de las Distancias de Siembra Entre Plantas y Entre Lomillos. Tesis de Grado, Universidad de Costa Rica: 1962.
6. Asociación Nacional del Café. Programa de Diversificación de ANACAFE. Guatemala: 1967.
7. Banco Central de Costa Rica. Proyecto de Repoblación y Mejoramiento de 35,000 Manzanas de Café. A report to the Oficina de Planificación, Presidencia de la República. San José: 1965.
8. Barclays Overseas Survey 1968. London: Barclays Bank, 1968.
9. Barnes, Hester. Proyecto de Diversificación de Turrialba--Un Esfuerzo Municipal. A project report prepared for the Comité de Diversificación. Turrialba, Costa Rica: 1968.
10. Benavides Rohles, Oscar. The Agriculture of the Rio Grande River Valley of the Central Plateau, Costa Rica with Special Emphasis on Coffee Farms. Thesis. Ithaca, New York: Cornell University, 1957.
11. Dieber, John L. An Economic Analysis of Diversification of Coffee Producing Areas, Costa Rica. A University of Florida report prepared for the U. S. AID Mission in Costa Rica. San José, Costa Rica: 1968.

12. Brooke, D. L. and R. L. Qualls. Production and Marketing of Florida Strawberries. Agricultural Economics Mimeo Report EC 67-3. October, 1966.
13. Brown, Lester R. "The World Food and Population Problem." Foreign Agriculture, 5 (5): 3-4. January 30, 1967.
14. Caro Costas, Ruben, Jose Vincente Chandler, and Jacinto Figarella. "Productivity of Intensively Managed Pastures of Five Grasses on Steep Slopes of Humid Mountains of Puerto Rico." Journal of Agriculture of the University of Puerto Rico, 49 (1): 99-111.
15. Carvajal, Manuel J. and James E. Ross. Fact Sheets on Costa Rican Agriculture. A University of Florida report prepared in cooperation with the U. S. AID Mission in Costa Rica. San José, Costa Rica: 1968.
16. Castillo, Carlos M. Growth and Integration in Central America. New York: Frederick A. Praeger, Publishers, 1966.
17. Castro, Juan J. and James E. Ross. Factors Affecting Agribusiness Investment in Costa Rica. A University of Florida report prepared in cooperation with the U. S. AID Mission in Costa Rica. San José, Costa Rica: 1969.
18. Collado, Oscar. "Costo Promedio de Producción por Manzana de Cultivo." Work Sheets of Sección de Juntas Rurales de Crédito Agrícola, Departamento de Crédito Rural, Banco Nacional de Costa Rica. 1967.
19. Consejo Superior Universitario. Oferta y Demanda de Recursos Humanos en Centroamérica. Estudio de Recursos Humanos en Centroamérica No. 6. Ciudad Universitaria, Costa Rica: 1966.
20. Culp, Thomas W. Castorbean Production in the Mississippi Delta. Mississippi Agricultural Experiment Station Bulletin 6775. 1963.
21. _____. Sesame Production in the Mississippi Delta. Mississippi Agricultural Experiment Station Bulletin 674. 1963.
22. Delrymple, Dana G. The Diversification of Agricultural Production in Less Developed Countries. A report of the International Agricultural Development Service, U. S. Department of Agriculture. Washington: 1968.
23. Dirección General de Estadística y Censo. Censo Agropecuario 1963. San José, Costa Rica.
24. _____. Comercio Exterior de Costa Rica 1968. San José, Costa Rica.
25. _____. Unpublished computer output summarizing the 1963 agricultural census by district for major crops. San José, Costa Rica.

26. Facultad de Agronomía. Informe de Trabajo Anexo de Horticultura, Estación Experimental Agrícola "Fabio Baudrit Moreno." A report of the Universidad de Costa Rica. 1963.
27. Fernandez, Carlos Enrique. 'Adaptación de la Producción Latinoamericana de Café a la Demanda Mundial.' Revista Cafetalera. Octubre de 1967, 29-31.
28. Florida Department of Agriculture. Citrus Summary. Florida Agricultural Statistics. 1966.
29. Food and Agriculture Organization. "Coffee Production." Monthly Bulletin of Agriculture and Statistics, 17 (11): 21. November, 1968.
30. Gilbert, Alvin E. "Coffee in Latin America: A Blessing and a Burden." Foreign Agriculture, 5 (15): 10. April 10, 1967.
31. Gooding, H. J. "The Agronomic Aspects of Pigeon Peas." Field Crop Abstracts, 15 (10): 1-5. 1962.
32. Haarer, A. E. Modern Coffee Production. London: Leonard Hill Limited, 1962.
33. Heady, Earl O. and Wilfred Candler. Linear Programming Methods. Ames, Iowa: The Iowa State University Press, 1958.
34. International Coffee Agreement, 1968. World Coffee Information Center. Washington. "Diversification Fund" Chapter XVI, Article 54.
35. "Israel Expands Strawberry Market." Foreign Agriculture, 7 (38): 16. September 22, 1969.
36. Junta de Defensa del Tabaco. Investigación Sobre Producción e Ingresos del Tabaco. San José, Costa Rica: 1967.
37. Kennen, Peter B. International Economics. Englewood Cliffs, New Jersey: Prentice Hall, Inc., 1964.
38. Kinman, Murray. "Sesame as a Domestic Industrial Oilseed Crop." Chemurgic Digest, 13: 6-8. February, 1964.
39. Kraft, John H. "A Year of Progress in Sesame." Chemurgic Digest, 17: 4. April, 1958.
40. Krauss, F. G. The Pigeon Pea (Cajanus indicus) its Improvement, Culture and Utilization. Hawaii Agricultural Experiment Station Bulletin No. 64. March, 1952.
41. Krezdorn, A. H. Potential Fruit Crops (other than citrus) for the Atlantic Zone of Costa Rica. A University of Florida report prepared for the Agency for International Development. Gainesville, Florida: 1967.

42. Krome, William H. "Economic View of Lime Growing in Florida." Economic Botany, 22 (3): 270-272. July-September, 1968.
43. Lansen, Paul. "Plastic Mulching is a Profitable Practice." American Fruit Grower, 87 (3): 30-32. March, 1967.
44. Leftwich, Richard H. The Price System and Resource Allocation. New York: Holt, Rinehart and Winston, 1966.
45. Lockley, Lawrence C. A Guide to Market Data in Central America. Bank for Economic Integration, Tegucigalpa, Honduras, 1964.
46. Magleby, R. S. "Agricultural Geography: Latin America in Transition," Foreign Agriculture, 5 (15): 11. April 10, 1967.
47. Martin, John H. and Warren H. Leonard. Principles of Field Crop Production. New York: The Macmillan Company, 1949.
48. Millikan, Max F. and David Hapgood. No Easy Harvest. Boston: Little, Brown and Company, 1967.
49. Ministerio de Agricultura de Guatemala. Costos de Establecimiento, Mantenimiento y Cosecha de los Cultivos de Hule, Cacao, Citricos, Vainilla, Jocote Marañón, Soya, Pina, Coco, Mango, Papaya y Pimiento Negro. An economic report prepared by the "Los Brillantes" Experiment Center. Mulua, Retalhuleu: 1968.
50. Ministerio de Agricultura y Ganaderia. Cultivos Agrícolas de Costa Rica Manual de Recomendaciones. Boletín Técnico No. 35. San José, Costa Rica: 1965.
51. _____. "Producción de Frijoles en la Zona de Atenas--San Josecito (Alajuela) Costa Rica." Proyecto de Investigaciones Economicas. P. 36--No. 3. Marzo, 1962.
52. Murillo Arguero, Gilbert. Pueba de Rendimiento con Variedades de Pepino. Boletín Técnico No. 41. Ministerio de Agricultura y Ganaderia. San José, Costa Rica: 1963.
53. Newman, Peter. Economic Analysis of the Problem of Coffee Surpluses. A report from Robert R. Nathan Associates to the Oficina de Planificación, Presidencia de la Republica. San José, Costa Rica: July, 1966.
54. Oficina del Café. Algunas Consideraciones en Relacion con la Actividad Cafetalera en Costa Rica. San José, Costa Rica: 1967.
55. Oficina de Planificación. "Características y Problemas de la Economía Nacional 1950-1966." Situación y Perspectivas de la Economía Costarricense, Programas a Ejecutar en 1968 y sus Bases Presupuestos. Presidencia de la Republica. San José, Costa Rica.

56. Compendio de Cifras Básicas de Costa Rica IV. Sector Agropecuario 1950-1967. Presidencia de la Republica. San José, Costa Rica.
57. Organization of American States, Pan American Union. Production and Export Capabilities for Certain Agricultural Products in Raw and Processed Form in Central America. Washington: 1966.
58. Ospino, V. F. Manual de Costos Básicos de Actividades Agropecuarias. Banco de Crédito Agrícola de Cartago. San José, Costa Rica: 1966.
59. Pan American Coffee Bureau. Coffee and the U. S. Consumer. New York: 1964.
60. Pitcher, S. "Brazil's Coffee Tree Eradication Program as of Today." Foreign Agriculture, 3 (22): 67. August 16, 1965.
61. Scholl, John C. "Mexico's Grain Problem: A Production Boom That Won't Turn Off." Foreign Agriculture, 5 (27): 7. July 3, 1967.
62. Schultz, Theodore W. Economic Crisis in World Agriculture. Ann Arbor, Michigan: The University of Michigan Press, 1965.
63. Transforming Traditional Agriculture. New Haven, Connecticut: The Yale University Press, 1964.
64. Servicio Meteorológico Nacional. Boletín Meteorológico Año 1965. San José, Costa Rica.
65. Sherman, W. B. and P. J. Westgate. Blackberry Production in Florida. Florida Agricultural Extension Service Circular 325. May, 1968.
66. Tolley, G. S. and G. D. Gwyer. "International Trade in Agricultural Products in Relation to Economic Development," pp. 403-447. Agricultural Development and Economic Growth, eds. H. M. Southworth and B. F. Johnson. Ithaca, New York: Cornell University Press, 1967.
67. Tosi, Joseph A., Jr. and Robert F. Voertman. "Some Environmental Factors in the Economic Development of the Tropics." Economic Geography, 40: 189-205. July, 1964.
68. Tropical Agricultural Management Co., Inc. A Proposal for Crop Diversification in Costa Rica. A report prepared for the U.S. AID Mission in Costa Rica. Miami: 1967.
69. Universidad de Costa Rica. El Desarrollo Económico de Costa Rica, Estudio No. 3, Sector Agropecuario de la Economía Costarricense. Ciudad Universitaria, Costa Rica: 1969.

70. Uribe-Ruiz, J., M. E. Aragan and A. T. Viterbo. "Contribution to the Agronomic and Chemical Study of the Buckwheat (Polygonum facopterum) cultivated in Mexico." Revista de Sociedad Quimica Mexicana, 5 (4): 129-131. 1961. From Biological Abstracts, 41: 24454.
71. Vargas Vaglio, Oscar and Jose Alberto Torres. Estudio Preliminar de Suelos de la Region Occidental de la Meseta Central, Boletín Técnico No. 22, M.A.I. San José, Costa Rica: 1958.
72. Weiss, E. A. "Dwarf Castor." World Crops, 18 (12): 43-49. December, 1966.
73. Wellman, Frederick L. Coffee: Botany Cultivation and Utilization. London: Leonard Hill Limited, 1961.
74. Welton, Richard S. "El Salvador Plans Crop Diversification to Spur Its Economy." Foreign Agriculture, 5 (32): 5-6. August 7, 1967.
75. Wilson, Dalton L. "Guatemala--and Its Flourishing Rubber Industry." Foreign Agriculture, 5 (29): 3-4. July 17, 1967.

BIOGRAPHICAL SKETCH

John Lewis Bieber was born August 15, 1936, at Lafayette, Indiana. He grew up on a general purpose farm near Lafayette and graduated from Buck Creek High School in 1954. He then attended Purdue University where he received the degree of Bachelor of Science in Agriculture in June, 1958, with a major in Agronomy.

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Mr. Bieber served in the United States Air Force. He entered the Graduate School of the University of Florida in January, 1964. He left the University in May, 1965, and farmed two years in Indiana. In September, 1966, he returned to the University of Florida and continued work toward the degree of Doctor of Philosophy in Agricultural Economics.

In July, 1967, Mr. Bieber began research under the U. S. AID/University of Florida Contract in Costa Rica. He received an interim staff position in November, 1968, with the University of Florida in order to carry out additional investigations of crop diversification in Costa Rica. In January, 1970, Mr. Bieber again entered the University of Florida to complete the requirements for the Doctor of Philosophy degree.

John Lewis Bieber is married to the former Martha Eugenia Stelle. He is a member of Gamma Sigma Delta.

This dissertation was prepared under the direction of the chairman of the candidate's supervisory committee and has been approved by all members of that committee. It was submitted to the Dean of the College of Agriculture and to the Graduate Council, and was approved as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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