A quota system policy and its impact on the labor market in the sugarcane industry analyses through dynamic linear programming procedure, Sao Paulo, Brazil

by

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CHAPTER I. INTRODUCTION

In the study of a foreign country, it is useful to know some of its geographical and historical background. Otherwise, some strange preconceptions may exist. Therefore, I have briefly described Brazilian geography and history, as well as the history of the State of Sao Paulo with emphasis on the agriculture of this state and its relation to the Brazilian agricultural economy.

Geography of Brazil

Brazil is 3,286,473 square miles in size (41). In area it is almost the same size as the United States. It is greater than the U. S. if one excludes Alaska. Brazil can be divided into five general geographical regions: North, Northeast, East, West-Central and South.

As we can see in Figure 1, the North region includes the three states of Para, Amazonas and Acre. These states have not developed yet economically; recently, however, through government leadership, the trans-Amazon highway has been completed from the northeast coast to Peru. This highway runs parallel to the Amazon river with a total distance of approximately 3,000 km. By means of government promotion it is expected this region will be developed at a fast pace. Traditionally this region has used an extractive agriculture. The principal products are rubber, para nuts and pepper.

Figure 1. Map of Brazil: Five geographical regions and population densities of each state (inhabitants per sq km, 1960)


NORTH
NORTHEAST
EAST
WEST - CENTRAL
SOUTH
AMAZONAS
PARÁ
MARANHÃO
CEARÁ
RIO GRANDE DO NORTE
PERNAMBUCO
ALAGOAS
SERGIPE
BAHIA
MINAS GERAIS
ESPÍRITO SANTO
RIO DE JANEIRO
GUANABARA
SÃO PAULO
PARANÁ
SANTA CATARINA
RIO GRANDE DO SUL
DISTRITO FEDERAL
TERRITÓRIO DO RIO BRANCO
TERRITÓRIO DO AMAPÁ
TERRITÓRIO DE RONDÔNIA
ACRE
.5
1.3
7.7
22.6
21.9
35.8
42.1
46.
34.6
5.
.8
3.
10.7
16.8
30.2
80.8
52.3
21.5
22.5
20.5

Table 1. Area, population and density of Brazil's five geographical regions 1970[a]

Regions	Area		Population		
	Km^2	% over total of Brazil	No. of inhabitants	% over total of Brazil	Density per Km^2
North	3,581,180	42.1	3,650,750	3.9	1.03
Northeast	1,548,672	18.2	26,675,081	30.3	18.59
East	924,935	10.8	40,331,969	42.7	43.90
South	577,723	6.8	16,683,551	17.6	29.68
West-Central	1,879,455	22.1	5,167,203	5.5	2.75
Brazil	8,511,965	100.0	94,508,554	100.0	11.18

[a] Source: Fundaeao Instituto Braseleira de Geografia.

The Northeast region includes seven states that are small compared to the states of the other regions. These states are old historically, since Brazil was colonized from the northeast after Cabral's discovery of the area in 1500. This region originally was the most developed region due to the influence of European countries. The population was heavy. However, today it is not as densely populated as the East and South.[1] Because heavy emigration had occurred from the Northeast to the East and the South in the last three decades, the government recently put special emphasis on the redevelopment of the Northeast. Consequently, the rate of economic growth in 1973 was 14%,[2] the highest rate of growth in Brazil compared with the East and South which had 10 to 12% of the economic rate of growth in 1973.

The East region includes four states. The larger states are Minas Gerais and Bahia. The smaller states are Eipirito Santo and Rio de Janeiro. Bahia has good climatic conditions for cocoanut production, which is its most important industry. However, many oil wells have been discovered here recently as well as in the Northeast region. The oil industry will undoubtedly be an important industry in the future.

In the state of Minas Grerais there exists one of the largest deposits of iron ore in the world. This mineral continues to be an

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[1]Table 1, Regional Distribution of Brazilian Population, 1960. Anuario Estaticotico do Brasil 1973.

[2]Boletin Informatino da Embaixada do Brasil.

important source of foreign currency for Brazil, even though recently the importance of iron ore as an export has been reduced by the substitution of such semimanufactured products as steel, some parts of automobiles, and such food industries as edible oil, especially for Latin American countries and for Europe.

The city of Rio de Janeiro was the capitol of the nation until 1960 when the capitol was transferred to Brazilia in the state of Goias in the Central region. The two most important industries of the state of Rio de Janeiro are manufacturing and sugarcane. The city of Rio de Janeiro is especially appealing to travelers; therefore, the tourist industry is another important source of income for the state.

The West-Central region includes two states: Mato Groso and Goias where the new capitol of the nation is located. The new capitol construction in this West-Central region has provided great incentives for the development of the region.

The most important agricultural asset of this region is the cattle industry. However, since the opening of highways from Sao Paulo to Brasilia and Brasilia to Belem various other agricultural enterprises have been introduced. Furthermore this highway was completely paved in 1973 and it is expected that a major industrial development along the highway will follow.

The fifth region is the South Region, most populated and most industrialized of all Brazilian regions. It includes the following states: Sao Paulo, Parana, Santa Catarina and Rio Grande do Sul.

Sao Paulo is the most populated state in Brazil with a density per km^2 of 52.3. Industries range from the toy industry to the airplane industry, totally sponsored by the Brazilian government.

The state of Parana produces many such pulp trees as pines and eucalyptus. Recently, the production of soybeans and coffee has grown enormously.

The state of Santa Catarina has a type of textile industry that is a multinational industry. There is also some production of apples and peaches. The thriving coal industry contributes to the steel industry in the state.

The southeastern state of the nation is the state of Rio Grande do Sul where there are many manufacturing industries as well as such primary industries as livestock and viniculture.

Climate

Climate is of course closely related to such primary industries as agricultural production.

The annual average temperature of Brazil shows a predominance of hot weather with no average figure above 28°C or below 16°C. The extreme figures of temperature are exceptional as we can see in the record temperature of 43.8°C in the state of Bahia, and in the low record temperature of 14.1°C below zero in the state of Rio Grande do Sul. Generally, the mean temperature of Brazil is around 20°C.

Total precipitation is generally above a 1,000 mm excluding some excessive extremes of precipitation.

Geography and a brief aspect of economy of Sao Paulo

The size of the state of Sao Paulo is 247.88 km^2 which occupies 2.9% of the total area of Brazil. This state is divided into three principal parts: the coastal region, the high plateau region and the interior region.

The coastal region contains the port that was developed primarily for the export of coffee and bananas, the state's chief products. Today, this port has an important role in the economy of the state of Sao Paulo as well as the economy of Brazil. It is very important for the export of industrial semimanufactured products and the import of industrial materials from other countries.

In the tropical humid climate characteristic of this region, the annual average temperature is around 22°C to 23°C and the total annual rainfall is around 2,000 to 2,500 mm.

The high plateau inland region includes the capital city Sao Paulo, which has around 8 million population. This region has an altitude of from 200 to 800 mm above sea level and is very mountainous. However, viniculture is very adaptable to this region.

The average oscillation of temperature of this region is 18°C to 20°C. With the influence of altitude, the temperature is lower than that of the coastal region. The total annual precipitation is from 1,000 to 2,000 mm, and the climate is cool and comfortable to live in throughout the year.

In the interior of the state, where an agricultural region extends to the territory of the state of Parana, many such agricultural products as sugarcane, coffee, rice, corn, cotton, bananas, vegetables and citrus fruits are widely grown.

The annual total precipitation ranges from 1,100 mm to 1,700 mm, and the average annual temperature is approximately 18°C to 24°C.

A Brief History of Agriculture of Brazil

The Brazilian economy began with the usual extractive primary products which, since 1500, have been exported to European countries. Because of its dependency on foreign markets the Brazilian export economy has been greatly influenced by the foreign markets. But through the change in demand for special products, the same products that traditionally have been exported from Brazil are now eliminated from the Brazilian economy. In Brazil this kind of decline of primary products is called a "cycle." Several products belonged to this category before modern industrial production began; for example, gold, pepper, a Brazilian wood used to tint textiles in Europe, sugarcane, tobacco and coffee. From these traditional products coffee and sugarcane are still the most important products.

The primary extracting industries of pepper and Brazilian wood had their beginnings in the Northeast. Afterward they migrated to the East and South. Along with their exploration was the discovery of gold and precious stones around 1650 to 1700. This period was the gold rush in Brazil. Gold and diamonds were discovered to be plentiful in the state of Minas Gerais. In the eighteenth century, after these deposits were exploited, such agricultural products as cotton, tobacco and cattle again thrived. The industrial revolution in England was then consuming much cotton in its textile industry and cotton export production turned out to be a most important industry in Brazil.

Rubber production, begun at the end of the last century, rapidly occupied a most important position in the Brazilian economy with the chief production area in the Amasonas. In 1910 rubber made up approximately 42% of the total export of Brazil. With the growth of new rubber production areas in south Asia, however, the Brazilian rubber industry suffered low prices and by 1950 almost all the rubber industry was wiped out.

Coffee was introduced from French Guiana in 1727 in the state of Rio de Janeiro. The production of coffee has increased since the end of the 18th century. In 1826 the export of Brazilian coffee occupied 20% of total world export of coffee production. The increased demand for coffee initiated further expansion of this market. The production area moved into the state of Sao Paulo from the original state of Rio de Janeiro at the beginning of this century. Furthermore, since the 1960's, the production of coffee has been moving into the state of Parana which has more suitable soil and climatic conditions for coffee production. The important role of coffee to Brazilian economy is seen in Table 2.

Table 2. Quantity and value of the export of coffee and its relation to total exports, Brazil, 1900-1909/1960-1969[a]

Periods	Coffee: Total of sack of 60 kg	Coffee: Value in U.S. $1,000.00	Total export value in U.S. $1,000.00	% of export of coffee over total export
1900-1909	12,979,925	115,036	217,193	53.0
1910-1919	11,970,189	120,857	325,494	52.5
1920-1929	13,576,874	272,681	400,389	68.1
1903-1939	15,015,661	159,496	292,878	54.5
1940-1949	13,539,177	279,938	707,963	39.5
1950-1959	14,893,075	915,900	1,446,532	63.3
1960-1969	17,113,643	742,955	1,589,628	46.7

[a]Source: Instituto Brasileiro do Cafe, Banco do Brasil--CACEX (31).

A Brief History of Agriculture in the State of Sao Paulo

The exploration of agriculture of the State of Sao Paulo began from the coastal region to which private expeditions brought some subsistence crops for their colonization. Although these early expeditions came equipped with agricultural tools and seeds, their sites were not chosen on the basis of any virtue of the land, but rather by news of the existence of rich gold deposits in the area.

Using the initial colony as a base, expeditions explored and established new colonies in the high plains area, around 700 to 800 ms above sea level. With the opening of the plains, new crops were introduced--principally manioc, corn, wheat, barley and grapes--crops familiar to the European colonizers.

The expansion of agriculture as a result of this high plains colonization required an increasing supply of labor. Initially these demands were met by employing pacified Indians. However, it was soon necessary to round up and enslave large groups of unpacified Indians for this purpose. The captured Indians had difficulty working in agricultural production because their life was an extractive one, not an agricultural one. This required the employment of a larger number of Indians for the colonizing workers and the search for more Indians plus new of gold deposits and of precious stones in the interior of the state of Sao Paulo stimulated many ambitious expeditions moves toward the interior.

The relatively rapid exhaustion of the mineral riches led to the termination of the expeditions, bringing about some stagnation of agriculture in Sao Paulo, even though several such agricultural products as tobacco and leather, though not so profitable as gold and precious stone were needed for subsistence.

Introduction of coffee

An escape from economic stagnation came in the form of coffee, the culture of which began to expand into Sao Paulo from the neighboring state of Rio de Janeiro at the end of the 19th century. This introduction of coffee into Sao Paulo was encouraged by the demands of the world market. Furthermore, the state's climatic soil conditions were nearly ideal for coffee production, and land and labor were abundant.

Coffee is a commercial product especially suited to exportation. A coffee crop needs large quantities of labor for planting and cultivation without mechanization. Consequently, food crops to feed labor forces of coffee plantations are necessary. This need developed production of such crops as rice, beans, corn, potatoes and citrus fruits. Not only did these crops permit more efficient resource use but they also provided alternative income possibilities during periods of low coffee prices. The production characteristics of coffee stimulated a polycultural agriculture and established the basis for commercial production of a wide range of both crop and livestock products.

With the growth of coffee production at the end of the 19th century, the infrastructure of the state developed rapidly. New roads were opened; new railroads were constructed for the transportation; new lands were cleared and planted in coffee; and port facilities (such as Santos) were enlarged. Quite a few immigrants arrived to work on coffee plantations. This immigration increase was stimulated after the abolition of slavery in 1888. Overall economic development proceeded at a rapid pace throughout the state's economy.

The coffee boom lasted throughout the first three decades of this century. In this 30-year period Sao Paulo produced more coffee than all other producing countries combined. This concentration of coffee production in turn implied a high concentration of wealth in a relatively small area. All economic sectors benefited, including the industrial sector which could import machinery from developed countries with the foreign exchange gained by the export of coffee.

The coffee boom was terminated by the world economic catastrophe in 1929 and with the demise of the all-important coffee export market, the agricultural sector underwent profound change.

Even before the world economic depression, the state's coffee production had begun to change under the extraction-production procedure. Coffee was planted after clearing land, but fertilizers were not used for the coffee cultivation. Consequently, when production continued two or three decades, the actual coffee land was abandoned because of a drastic fall in production. Then new land was opened in the interior of the state. These abandoned or wornout lands were shifted to other crops and to livestock production.

Under these conditions, agricultural diversification of Sao Paulo proceeded very rapidly (11). Particularly important in the diversification process was spectacular growth in cotton production. In a period of only 9 years, cotton output expanded from an insignificant amount to an annual volume nearly equal to that of Egypt's, one of the world's principal producers. As a result, the state's agriculture was compensated substantially for the immense losses it had suffered and continued to suffer as a consequence of problems in the coffee economy.

Although in a much less important way than cotton, citrus and sugarcane production also increased. Sugarcane benefited from the national sugar policy that had been instituted to stimulate the Northeast's sugar industry. Taking advantage of these favorable policies, Sao Paulo's sugar output expanded to the point at which the state became Brazil's first leading producer.

During World War II Sao Paulo's agriculture suffered from the lack of sufficient wartime transport which brought about large export stock accumulations as well as critical fuel and petroleum product shortages. Internal transport difficulties hindered the production and marketing of agricultural products required by the growing urban centers. In many respects, however, the world conflict stimulated further diversification of Sao Paulo's agriculture. Especially, the effort of self-sufficiency for foodstuffs was promoted by the government. This governmental policy implies stimulation of the production of cereals (11).

After World War II, many difficulties disappeared and foreign exchange accumulated. However, this consequence of the wartime problem solution brought about new agricultural problems; i.e., agricultural adjustment problems. During this period of adjustment many coffee plantings had been abandoned due to low prices, and although postwar coffee prices stimulated new plantings, the bulk of these occurred in the neighboring state of Parana where the new land was more fertile and gave better production for coffee. On the other hand, Brazil's rapid industrial development during the war years and the consequent growth of the urban population brought about significant shifts in demand for agricultural products. The agricultural sector responded with marked increases in the production of peanuts, corn, rice, poultry and especially fruits and vegetables.

During the 50's the agricultural development of the State of Sao Paulo was characterized by continued disorders which were a reflection of the unstable political and economic situation of the country. Government policy of this period strongly favored the industrial sector, adding further distortions to the economic condition of agriculture. Retail and wholesale price controls were maintained on many farm products and not infrequently prohibitions were established on agricultural exports (11).

In spite of the unfavorable economic and political climate, considerable progress occurred in the adoption of new agricultural technology. With high coffee prices prevailing through much of the decade, coffee acreages expanded rather rapidly. In contrast to the expansion patterns of earlier decades, many new plantings took place in the old production zones. This return of coffee production to the old producing regions was accompanied by a heavy emphasis on the application of modern agricultural techniques. Selected varieties, recommended spacings, soil conservation, intensive use of chemical fertilizers, and other good practices were used, differentiating between modern technical processes and the traditional methods that predominated throughout the state.

Cotton production declined rather rapidly in light of the unfavorable international situation for the product. However, its decline was offset by increased production of peanuts. This crop found a ready market due to the growing demand for vegetable oils. More favorable production conditions in the neighboring state of Parana resulted in the transfer of potatoes, mint and ramie (hemp) from Sao Paulo. Corn production expanded, due to improved production practices and the increased use of hybrid seeds, while rice and edible beans--typical subsistence crops--underwent rather marked declines in production and yield.

Sugarcane and livestock production, including milk, expanded continually throughout the decade. In the case of sugarcane, producers were guaranteed stable and favorable prices through federal government policies.

Brazil's rapid industrialization had marked impacts on the agricultural sector. In addition to direct economic benefits, industrial development also resulted in agricultural infrastructure improvements. Electrical energy systems were expanded to the rural areas: transportation systems were enlarged and improved; communications systems developed; and banking and commerce, were extended throughout the state.

Position of Sao Paulo's agriculture

In order that the reader understand Sao Paulo's economic position in relation to the economy of Brazil I paraphrase the very adequate description of the Secretary of Agriculture of the state of Sao Paulo.

The state of Sao Paulo has, for many years, maintained a very dominant position in the Brazilian economy. Even though the state has only 17% of the nation's population and only 13% of the country's arable land area, it presently produces, and has produced during the past two decades some 35% of Brazil's national income. In aggregate terms, since 1948, its factories have produced an average of considerably more than half the country's industrial output; its farms more than a quarter of the nation's agricultural production; and its service sector nearly a third of the national income derived from this economic sector (Table 3).

As the nation's most developed state, Sao Paulo accounted for more than 50% of all taxes collected in the nation during 1969 (11). The state budget for that year was equal to more than 40% that of the federal government. Compared to other states the annual budget of Sao Paulo in 1970 was more than 3.5 times that of the next richest state and was equivalent to more than 70% of all the other state budgets combined (11).

Fiscal resource comparisons of this sort reflect the relative differences in the economic and social infrastructure of the state as compared to the rest of the nation. Statistics show that Sao Paulo, over time, made very heavy investments in social overhead capital

Table 3. National income percentage contribution of Sao Paulo's economic sectors to respective sectors of the Brazilian economy[a]

Year	Total	Agriculture	Service	Industry
1948	35.6	32.9	31.9	47.1
1949	35.4	32.0	32.1	46.4
1950	35.2	31.3	33.0	44.1
1951	36.1	33.3	33.1	45.4
1952	36.6	35.4	34.1	43.6
1953	35.9	32.2	33.9	43.5
1954	36.4	33.0	34.0	44.7
1955	38.7	32.7	33.7	34.4
1956	37.8	30.0	31.6	56.6
1957	38.4	33.7	31.9	55.8
1958	40.7	34.2	32.9	60.2
1959	41.6	34.1	33.2	61.2
1960	35.2	32.3	21.7	60.6
1961	40.1	32.7	32.1	59.1
1962	40.2	29.9	32.2	60.4
1963	39.8	31.8	32.2	58.0
1964	38.6	27.1	31.2	58.3
1965	39.2	31.2	31.7	58.6
1966	38.9	28.2	31.7	57.8
1967	38.1	27.6	31.1	57.4
1968	38.2	26.9	31.0	57.1
1969	38.1	26.1	30.7	56.7

[a]Source: Data in table compiled The Instituto de Economia Agricola (IEA) from unpublished data of the Fundacao Getulio Vargas.

relative to the other states of Brazil. These investments--both private and public--are evident in all sectors of the state's economy. Particularly noteworthy, however, is the emphasis that has been given to the important areas of transportation, communication, education, and more recently, electrical energy of which the rural electrification program is noticeably unique.

For example, in 1972, Sao Paulo had some 16,571 kilometers of roads of which 60% were paved. This represented about 16% of all roads in Brazil and nearly two-fifths of all paved roads in the country. The 5,814 kilometers of railroads make up 19% of the nation's total. Of Brazil's 959 radio stations and 925 newpapers in existence in the late 60's, Sao Paulo had 254 and 324 respectively.[1]

Economy of Sao Paulo in Relation to the National Economy

During the past two decades, the average annual growth of Sao Paulo's economy has been more rapid than in any other state in the country. In addition, during this period structural changes in the economy of the state have been clearly greater than those taking place in the rest of Brazil (34).

Presently nearly one-half the state's income is derived from the industrial sector, in contrast with the income of the rest of the states in which this relationship is less than 25%. While one-eight

[1] IBGE. Anuario estatistico do Brasil. Departamento de Divulgacao estatistica, 1973.

of Sao Paulo's income is derived from its agricultural sector, in the rest of Brazil, agriculture contributes about one-fifth of the national income. Clearly, Sao Paulo is the nation's most developed state and in terms of traditional economic indicators, it represents many characteristics of developed economies.

A characteristic observed throughout the Brazilian economy has been the spectacular growth of the industrial sector and the long-term decline of the agricultural sector relative to their respective contributions to national income. This development tendency is particularly accentuated in the case of Sao Paulo's economy. The contribution of the industrial sector of the state grew from 30% in 1948 to 47% in 1969. In the rest of the country structural transformations have been somewhat slower; the industrial sector during this period increased its contribution from only 18% to 22% (11).

The relative decline of the agricultural sector has been especially notable in Sao Paulo. Agriculture's contribution to the state's income has fallen from 25% to 12.5% during the period between 1948 and 1969. In the rest of Brazil the same phenomenon has occurred, although the decline has been from 28% to 22%. This clearly represents a considerably slower structural transformation than that observed for Sao Paulo (34).

Position of Sao Paulo's Agriculture in Relation to the National Agricultural Economy

The contribution of Sao Paulo's agricultural sector to the national agricultural economy has varied from 26% to 35% in the last two decades with an average contribution of 31.3% over the entire 1948-1969 period. Until 1958, the year-to-year variations obscure any notable trends in the contribution of Sao Paulo's agriculture to national agricultural economy. By 1969 the contribution had declined to 26%. However, a comparison of the averages between the two extreme five year periods, i.e., 1948-1952 and 1965-1969, shows a decline in Sao Paulo's contribution from 33% to 28% (11).

This decline has been due to several interrelated factors. Clearly, a major factor was the end of agricultural expansion into new lands of the state. By about 1950 the state's expansion into virgin lands virtually ceased. In neighboring states, however, the opening of new lands continued at an accelerated pace. Some increases in the production of many of Brazil's important crops have been tied to the expansion of frontier cultivation. Sao Paulo's competitive position for these crops has been considerably reduced. Thus, much of Brazil's more recent growth in the production of such crops as coffee, cotton, rice and beans has taken place not in Sao Paulo but in neighboring states.

The state of Sao Paulo has not been slow in compensating for the loss of its traditional crops to other states. Rapid increases in the area and production of sugarcane, citrus and other fruits and vegetables took place during the 1950-1970 period. However, the substitution of these crops for the former traditional products was not of sufficient magnitude to make up for the loss of key crops--notably coffee and cotton. The result has been that Sao Paulo's overall growth in agricultural output has not matched that of the rest of Brazil.

The decline of Sao Paulo's agriculture relative to total Brazilian agricultural output is shown in Table 4. Of the 14 products considered in this table, Sao Paulo--in the three year period of 1948 to 1950--was the nation's leading state in the area of seven and in the production of six of these crops. Twenty years later Sao Paulo led, in terms of area, for only five crops, and in terms of production for six crops. The state's proportion of the nation's total area and production for six crops. The state's proportion of the nation's total area and production of many important crops deteriorated sharply during the twenty-year period. Whereas formerly Sao Paulo produced 55% of the nation's cotton and 47% of the coffee, at the end of the period this had declined to 29% and 27% respectively.

From Table 4 we can note four crops that have increased in production during a 20-year period: sugarcane, oranges, manioc, and tomatoes, even though other several crops such as peanuts and corn reduced their production participation in national production relatively.

Although the agricultural position of the state of Sao Paulo is decreasing in relation to national agriculture, the state is still the leading agricultural producer in Brazilian agriculture. And it is expected that this situation will continue for some considerable time.

Position of the Agricultural Sector in the Sao Paulo's Economy

The development pattern of Sao Paulo follows similarly those of other countries' models. This has been true especially during the last

Table 4. Participation of Sao Paulo to Brazilian agricultural output, 1948-50 and 1967-69[a]

Product	Harvested Area (ha)				Quantity (tons)			
	1948-50 %	Rank	1967-69 %	Rank	1948-50 %	Rank	1967-69 %	Rank
Cotton	45.64	1°	11.4	4°	55.28	1°	25.7	1°
Peanuts	85.06	1°	80.8	1°	85.41	1°	78.9	1°
Rice	32.94	1°	16.2	4°	22.24	1°	13.4	4°
Bananas	20.96	1°	15.6	1°	18.07	2°	13.9	2°
Potatoes	32.88	2°	20.1	2°	35.00	2°	26.2	1°
Coffee	52.54	1°	29.5	2°	47.40	1°	29.9	2°
Sugarcane	16.76	3°	29.5	1°	20.05	1°	35.3	1°
Onions	35.08	1°	19.7	2°	23.19	2°	18.1	2°
Edible beans	14.63	2°	6.7	6°	14.66	3°	5.8	7°
Oranges	23.26	2°	44.0	1°	17.44	2°	42.8	1°
Castor beans	23.09	1°	16.0	3°	21.59	2°	16.6	2°
Manioc	4.90	6°	5.3	8°	6.50	6°	6.9	5°
Corn	18.97	2°	14.0	4°	20.55	2°	17.8	2°
Tomatoes	23.60	2°	34.7	1°	39.19	1°	43.2	1°

[a]Source: Instituto Brasileiro de Geografia Estatistica. I.E.A.

two decades. The percentage of agricultural income to total income has steadily decreased during these two decades. The migration from rural to urban areas after 1962 can be seen clearly from Table 5.

The decrease of agricultural income against non-agricultural income is seen in the rate of growth of agricultural income which is slower than the rate of non-agricultural income (Table 5). However, this does not mean that the rate of growth of income per capita of the agriculutral sector is lower than that of the non-agricultural sector. Rather, the rate of growth of agricultural income per capita is much greater than that of non-agricultural income per capita (11).

The absolute income per capita in the agricultural sector has increased very rapidly during the last two decades. It has nearly doubled. However, the absolute income per capita of the non-agriculutral sector is not so much, as we can see in Table 5. Especially, since 1962, the absolute difference between agriculture and non-agriculture sectors has decreased. And the relative percentage figure of per capita income of agriculture to per capita income of the non-agricultural sector has increased from 40% in 1948 to 62% in 1969.

The reason for the above convergence between agricultural and non-agricultural income per capita is that there has been great migration from rural to urban areas. This is the usual pattern of economic development procedure and this is the fundamental means of economic development (25).

Table 5. Sao Paulo per capita income of the agricultural and non-agricultural populations, expressed in constant cruzeiros of 1949[a]

Year	Per capita income of the population		Difference between agriculture and non-agricultural sectors	
	Non-agricultural population[b] (A)	Agricultural population (B)	Absolute (A-B)	Relative % B/A
1948	10.45	4.25	6.20	40.67
1949	10.73	4.25	6.48	39.61
1950	11.03	4.32	6.71	39.16
1951	11.74	4.39	7.35	37.39
1952	12.36	5.04	7.32	40.77
1953	12.23	4.54	7.69	37.12
1954	13.38	4.98	8.40	37.22
1955	13.98	5.30	8.68	37.91
1956	13.85	4.75	9.10	34.29
1957	14.19	5.80	8.39	40.87
1958	15.67	6.06	9.61	38.67
1959	16.08	6.39	9.69	39.74
1960	13.13	6.38	6.75	48.59
1961	16.29	7.00	9.29	42.92
1962	16.49	6.84	9.65	41.48
1963	15.49	7.49	8.00	48.35
1964	15.01	6.60	8.41	43.97
1965	14.08	8.87	5.21	62.99
1966	14.43	7.99	6.44	55.37
1967	14.08	8.55	5.53	60.72
1968	14.75	8.78	5.92	59.52
1969	15.02	9.38	5.64	62.45

[a]Source: I.E.A.

[b]Income of the non-agricultural sector is expressed as the sum of the industrial and service sectors.

CHAPTER II. PROBLEM SETTING

Tendencies of Labor Forces in Agriculture Under Economic Development

This chapter is a summary of the fundamental pattern of economic development of agriculture, using, as examples, the United States, Japan and Brazil. The purpose of the review is to delineate the fundamental problems in agricultural development.

The chapter contains also a review of literature on dynamic linear programming, and lists five objectives of the present study.

The case of the United States

Conventionally, the relating of economic theory to the agricultural structure requires analysis from two sides: demand and supply. As many distinguished scholars, T. W. Schultz (37) and others (14, 36, 13) have estimated the elasticity of demand for foodstuffs, which is usually inelastic or of very low elasticity of demand for foodstuffs creates one side of the income problem of agriculture.

The problem on the other side is the supply of agricultural commodities. Usually, in the short run, the elasticity of supply of agricultural commodities is very low, even though the same elasticity is more elastic in the longrun. Furthermore, this elasticity of production and the elasticity of input supply influence on the elasticity of supply (14). Usually the production of agriculture occurs in stage II of the production function. This shows a decreasing rate of average productivity of input. This follows low elasticity of supply. This decreasing rate of productivity is dominated by the restriction of input factors. Usually these restrictions on input are land, capital or labor (10). However, in the case of Brazil, the restriction of input is capital rather than land, as is frequently seen in Asian countries.

Another fundamental factor that defines the elasticity of supply of agricultural commodities is elasticity of the input supply factor of production. There exists a seriously slow response of these input factors of production for price changes. This characterizes the elasticity of the input supply in the short run, even though considerable response of input supply for price changes exists in the long run. This is the characteristic of agriculture that fundamentally influences an agricultural income problem. These input factors of production are land, capital and labor. Land has low substitutability for non-agricultural uses even though it has great alternative uses within the agricultural production sector.

Capital use in agriculture is very fixed. Once capital is invested on a farm such as in a barn, tractor or a silo, this capital has no alternative uses outside of industry and this affects the elasticity of the input supply.

Labor, the most important factor of production of an economy, has also a very low response for the change of economic conditions in the short run. This is because of lack of knowledge for alternative jobs, lack of training for alternative jobs, age problems, preconception of transfer from rural to urban and the like. However, this is only a short run phenomenon. In the long run, labor shifts from the agricultural sector to other sectors in familiar patterns of economic development. This reduction of labor in the agricultural sector occurs with the increase of technology of this sector and the increase of productivity per capita. This is the conventional development of agriculture. As one can see in the research literature the agricultural population of the U. S. is decreasing at an astonishingly high rate (24, 25). Today the agricultural population is around 2% of the total. Naturally, this decrease of farm population has drastically increased the productivity per capita of the agricultural sector. Therefore, this is a sound and typical pattern of agricultural development (28).

Because of the experience of the U. S., the goal of agricultural development around the world is to reduce the number of people engaged in the supply of foodstuffs and of fiber and thereby increase productivity per person by technology through time. This goal could perhaps be interpreted as saying we could look for free foodstuffs and fiber in the future. But the fundamental problems of <u>speed</u> of shift of the labor force from the agricultural sector to the non-agricultural sector under technological change in the agricultural sector still exist and the rate of growth of the non-agricultural sector absorbs the flow of labor from the agricultural sector even though economic development is capital accumulation, and anti-employment tenant (26). Moreover, this labor shift is only counteracted by technological change.

The case of Japan

As a very naive economic development pattern, we should examine the example of Japan, even though its historical background is different from those of the U. S. and Brazil. The differences in Japan's historical background provided a different impact on the initial stages of its economic development, as is explained in the literature of Asiatic economic development. The typical models are Lewis (22) and Ranis and Fei (34). However, this difference exists only in the initial stage. The subsequent process of economic development is virtually the same as in the U. S. The output of rice, for example, which is the main foodstuff of Japan, doubled from 1900 to 1960. During this period land and capital inputs increased slightly while labor remained constant. This means that productivity per labor input increased tremendously during this period (31).

Furthermore, if we look at agricultural labor and total population in Table 6, we see drastic reduction in the agricultural labor force ratio to total population which, in 1970, was 9. This reduction of agricultural labor was made without any reduction of food production. And, in Ohkawa's estimation, this reduction of labor force increased labor productivity tremendously. Too, the total economic impact was made completely positive by intersectoral migration (18) and (21).

It should be noted that some of technological progress pattern of Japan is different from that of the U. S.: Japan preferred land improvement and seed research improvement procedures to mechanization procedures,

Table 6: Population: total and gainfully occupied by industry[a] (thousands), Japan

Year	Total population A	Agriculture population B	B/A%
1910	49,489	15,943	32
1920	55,885	14,663	26
1930	64,450	14,689	23
1940	71,933	14,323	20
1946	75,750	17,446	23
1950	83,200	17,208	21
1960	93,420	14,490	16
1970	103,720	10,060	9

[a]Source: (31, pp. 310, 311).

for example. Still, we agree with the general pattern of agricultural development's role in economic development.

The case of Brazil

Even though no good data to estimate the intersectoral migration over time are available, we can obtain some rough figures from the Brazilian demographic census.[1] Schuh (36) analyzes some rough intersectoral migration using detailed figures. His essential point is that the migration from rural to urban had a serious effect on Brazilian society since there existed an intersectoral dilemma during his analysis of 1940 to 1960: active working people could not find jobs in either urban or rural areas. Even though the rate of growth of industrialization was very high, this industrialization could not create enough employment opportunities for migrants from the rural area with their usual lack of training for industrial work.

In the underdeveloped countries some serious problems of imperfection of the labor market always exist. A normal transfer of the working force cannot occur smoothly as Schuh indicated (4) and (36).

State of Sao Paulo--Labor Force

As we see in Table 7, the agricultural population[2] of the state of Sao Paulo is decreasing constantly against that of the total population.

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[1]Brazilian labor force data are based on a concept of "potential labor force," which includes the population 10 years of age and over.

[2]The concept of agricultural population is a summation of various groups of people economically dependent upon agricultural production activities.

Table 7. Total agricultural population of State of Sao Paulo[a]

Year	Total population (1,000)	Agricultural population (1,000)	Percent of total agri. pop./total pop.
1948	8,522	3,825	44.9
1950	9,134	3,950	43.2
1955	10,631	4,135	41.0
1960	12,977	4,080	34.2
1965	15,383	3,750	24.4
1969	17,612	3,275	18.6

[a]Source: I.E.A. and Census.

In percentage terms, this decrease was 7% at annualy during the 20-year period, 1948-1969, even though we can see some increase of population from 1950 to 1955. In this same period, the total population grew constantly, from 8.5 million to 17.6 million in absolute terms. This rate of population growth is approximately 3.5% per year.

The average productivity of agriculture is shown in Table 8. The average productivity increased fairly constantly from 1948 to 1969, except for 1965's drastic increase--above U. S. $400 per capita. That figure decreased in 1969. The percentage increase of the value of per capita agricultural output was more than 60 during the 20 years surveyed. This figure is an interesting one when we consider the percentage decreases in the agricultural population.

Several other factors should be considered in the complete development process of the state of Sao Paulo; for example, the wages of agricultural labor and the educational structure or the degree of education of agricultural labor. However, we can in gross terms determine the pattern of agricultural development of the state of Sao Paulo through the other patterns that were described above, even though we cannot get absolutely confirming data for the delineation of the pattern.

We know the usual pattern of agricultural development through some gross presentations of the cases of other countries: agricultural population is shifted out as the agricultural productivity per capita is increased. Naturally, when the agricultural population is transferred from rural areas, alternative job opportunities through educational bases

Table 8. Measures of average human productivity in State of Sao Paulo agriculture, 1948-69[a]

Year	Aggregate value of production per agricultural population			Aggregate value of production per agricultural market	
	Cr $, 1969	U.S. $, 1968	Index 1948-52 = 100	Cr $, 1969	U.S. $, 1958
1948	897	219	95		
1950	971	237	103	2,506	612
1955	1,209	295	128		
1960	1,116	284	124		
1965	1,692	413	179		
1969	1,591	381	165		

[a]Source: I.E.A.

must be considered (37). Problems are obviously created in every gap among these processes. Taken the rate of the transferrence of agricultural labor is too fast for the absorption capacity of alternative job opportunities, a problem of labor force is created. However, the present study focuses on only rate of transferrence of agricultural labor.

As we noted in Tables 7 and 8, the value of per capita agricultural product decreased from 1965 to 1969, and the agricultural population continuously declined also. Here we see a departure from the developmental pattern: the flow of migration from rural to urban continues, but the productivity of agriculture per capita does not increase as we expect. This influences the profitability of the industrial sector through input cost, especially the wage rate and creates problems of employment opportunities for newcomers from rural areas.

Therefore, the question becomes: Can we keep the rural labor force in the agricultural sector through wage control rather than allowing them to face no employment opportunity in the city? Secondly, Is it possible to keep the labor force in the rural area without reducing much profit of this sector compared with the present optimization situation? The third fundamental question is: Would the government interference procedure be an inefficient one? Since the government interfers with production of sugarcane, through quota system control,[3] the question is whether this quota system reduces efficiency of

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[3]Explained in Chapter 3.

production. Furthermore, does the quota system counteract the absorption of the simple labor more in the rural area for the adequate rate of economic development?

Review of Literature, Dynamic Linear Programming

This section discusses only the role of the demand for the input and the supply of output and the application of dynamic linear programming to the farm firm, since the problems of migration as related to usual economic development process have been mentioned in the preceding section.

As any textbook explains, the demand of a firm for one variable productive service continues until the value of the marginal product of a variable productive service is equal to its price. This concept is the result of the profit-maximization-assumption in the marginal analysis (8, 10, 13, 15). If the production function is neoclassical in type, the demand function will be the smooth-continuous one. However, the linear programming type of demand function is a step function, since the production surface is not smooth as is the neoclassical production function as Baumol discusses well in his book (2).

Cesal (5) used this concept for an estimation of the resource demand function. He studied quantitative estimates of the effect of resource and product prices on the quantity of resources employed by the farm firm. He divided this general idea into the three principal objectives: 1) resource demand function; 2) price elasticity of resource demand with respect to the price of the resource, the price of other resources, and the price of products; 3) cross-resource demand functions.

The limitation of the demand function of linear programming is fundamentally a discontinuity of the function. This point can be applied to the supply function limitation (7).

The derivation of the supply function is usually defined in the perfect competitive market condition, for in the perfect competition market model each firm's goal is to maximize profits. The firms are "quantity" adjusters where any quantity produced can be sold at the current price (10). The supply function is derived from the competitive assumption and the profit maximization assumption as the marginal cost above the average variable cost in the neoclassical production function. If the price is below this average variable cost, the supply will be zero quantity (10, 15 and 2).

Cesal (5) and Heady (12) continue to explain the derivation of the supply function from the linear programming framework. The method of deriving a product supply function from a linear programming framework is analogous to the method used to derive a resource demand function from a linear programming framework.

This concept of linear programming will be introduced into dynamic linear programming with a one factor variable procedure or with a one product price variable procedure. No literature is available for this kind of application.

The application of dynamic linear programming in farm firm planning

Smith (39), Loftsgard (23), Chao (6), and Kay (20) recently have applied dynamic linear programming into the farm firm organization.

In his work, Smith (39) applied the dynamic linear programming technique in determining conservation plans for a period of 5 years. The technique represents an improvement over static analysis of conservation adjustment in that plans are specified for each year of the 5-year period. Specifically, the method can be used to determine the most profitable farming plan for each year under each conservation situation. However, his general fundamental objective is to develop a method of dynamic linear programming applicable to determining optimum farm plans for a 5-year period. In his specific objectives, he applied this technique of the dynamic linear programming in conservation. In his conclusion, he found that net return was highest when fertilizer and contouring and terracing were included, and lowest when neither fertilizer nor contouring nor terracing were used.

The net return used is the discounted net return over 5 years by 6% interest rate.

Loftsgard (23) tried to combine elements of home management in the planning framework by his dynamic linear programming. Further he placed his attention on the optimum livestock production combination for the change of its price. And he focused on the capital accumulation through the transfer of capital from one time period to another. The time dimension was 8 years.

Chao (6) selected a case farm in Taiwan and developed 5-year dynamic linear programming including home consumption. His central objective was to determine the optimum allocation of a single crop paddy farm. He also used nonlinear programming for the resource allocation as compared with dynamic linear programming.

The above applications of dynamic linear programming are primarily resource allocations over time, without considering the growth of the farm firm even though the researchers think the expansion of the farm firm is implied implicitly. Kay (20) explicitly applied the dynamic linear programming technique to the growth of the farm firm, using various types of expansion activities. These expansion activities are land renting; land purchase, mortgage; land purchase, contract; machinery purchase; labor purchase; livestock expansion facilities; and capital borrowing. He examined these activities over 8 years in order to verify the change of the farm firm organization in a sense of growth.

Objectives

The general objective of this study is to verify the impact on the labor market of the sugarcane industry policy of quota system control through the optimization of sugarcane enterprise and a specific regional aggregation of the state of Sao Paulo in order to approximate a solution for the problem of the agricultural development procedure that the state of Sao Paulo faces now. (This was discussed briefly in the section on problem delineation.)

Specifically, the present study tries to meet the following objectives in order to achieve solutions to the above problem:

1. To optimize the sugarcane enterprise for the various types of tractor capacities and combinations of them through dynamic linear programming procedure.

2. To estimate the demand for the hired labor in the sugarcane industry in the specific region of the state of Sao Paulo.

3. To compare the efficiency of productivity between the optimal level of production and the quota system controls.

4. To measure the impact on the labor market through the government interference policy of sugarcane production, i.e., the quota system control policy.

5. To estimate the supply impact of sugarcane by the change in the quota system policy.

These objectives are analyzed by models of the dynamic linear programming method over a 12-year period.

CHAPTER III. HISTORICAL, AGRONOMIC, AND DATA COLLECTION FACTORS

In this chapter a brief history is given of sugarcane in Brazil and its regional areas of production including the State of Sao Paulo. The chapter also provides a brief history of government interference in sugarcane production. Finally, the characteristics of the agronomical phases of sugarcane cultivation are given in order to enable readers to understand the structure of the matrix of the dynamic linear programming models that are presented.

Brief History of Sugarcane in Brazil and Geographical Distribution of Its Production Including the State of Sao Paulo

The first introduction of sugarcane into Brazil was around 1530 (32) to the east coast of the State of Paraiba. After introduction in that region, the cultivation of sugarcane was transported to southern regions, Rio de Janeiro and Bahia. The cultivation of sugarcane developed at a very fast pace to meet the European countries' demand for sugar. Brazil began as a colony of Portugal whose merchants covered all the markets of Europe with Brazilian sugar. Prosperity of sugar production in Brazil continued for about 150 years after its introduction into Brazil.

From approximately 1680 until the beginning of the 19th century the production of sugarcane remained at almost the same level. This stagnation resulted from the production of sugarcane by the central American countries in competition with Brazilian production. Another contributing factor was the development of the sugar beet which came out in mass production. It competed with sugarcane vigorously until World War I and pushed the price of sugar down in the international market. Therefore the production of sugarcane did not increase much these periods (32).

Furthermore, in Brazil the elimination of the slavery system was officially enacted as law in 1888. This influenced the input factor of labor in the sugarcane field, with some interaction of socioeconomic and political phenomena. A direct influence of this law was the reduction of labor input in sugarcane production. Consequently, without any improvement of productivity in that time a reduction of output of sugarcane occurred as well.

Until 1914, European countries developed nearly sufficient production for their consumption through sugar beet production. The United States had a good supply of sugarcane from Cuba. Therefore, the Brazilian sugarcane industry did not have any opportunity in the international market. During this period Brazil developed only the domestic consumption market for sugarcane, and exportation was a very small part of total production. Furthermore, after World War I, the strong competitive position of sugar beets came back to full production. Thus the sugarcane industry in Brazil was faced with overproduction. Its market price could not cover the cost of production.

It was a turning point for the Brazilian sugarcane industry when government intervention began. The official agency for the government control purpose, Instituto do Acucar e do Alcool, (I. A. A.) was created in 1932.

The government agency controlled sugarcane production by a quota system. A quota was decided by referring to the average production of the last 5 years. Through production control, this agency regulated the sugarcane market. Yet, the demand side was not considered seriously. The distribution of the total production of Brazil is divided into two principal regions of sugarcane production: the Northeast Region and the South Region. At the time of the creation of the government agency the principal production region was the Northeast (32) where the percentage of total production was 63, while the South produced only 37% of total production. However, these percentages were inverted at the beginning of the 1940's. The South Region today produces more than 65% of the total production of Brazil. Only the State of Sao Paulo produced more than 50% of the total production of Brazil in the 1970-1971 harvest. Sao Paulo benefited by the global industrial development that helped to increase its productivity of sugarcane over that of the Northeast Region.

Recently, this government agency intervened seriously in the quota system established a few decades ago. It also established, in 1971, new regulations to increase the efficiency of the sugarcane industry. These two policies are contradictory as this present study verifies. The old quota system and efficiency in the industry of sugarcane seem not to be compatible.

Zink and Goncalves (44) estimated 80 million sacks of sugar in 1971 which was the amount of production necessary for domestic consumption and exportation of 20 million sacks.[1] However, the real production of the 1966 to 1967 harvest year was only 61.8 million sacks which did not satisfy the export need. A deficit of 20 million sacks of sugar had serious impact on the domestic sugar market. More recently, since the change of the geopolitical map of world by Mr. Nixon, Brazil has gained in trade agreements a large export contract with the U.S.S.R. and Red China. This market demands more production of sugarcane to meet the domestic and foreign needs.

Agronomic Description of Sugarcane Operation

In the State of Sao Paulo, sugarcane generally is seeded from the beginning of the year, i.e., January to the end of March or sometimes the beginning of April. Several operations are needed before seeding. The first is the preparation of soil by harrowing in order to extract the old cane roots. After root extraction, a tractor-pulled plow is passed over the field about twice. If the land is rolling, some leveling procedure is needed to prevent soil erosion. After plowing, a disc harrow is usually run over the land in order to break up the plowed ground. Disc harrowing is usually done two times in the "Latosol"[2] soil, then a ditcher is used to make ditches of 10 to 15 inches depth. In these ditches fertilizer, some chemical formicides and lime are usually placed before the sugarcane is laid.

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[1]One sack of sugar weighs 60 kg.

[2]Soils of dark red developed shales; acid soils with a low base saturation and an amount of iron oxides (29).

The seed canes, which are 2 to 3 yards in length, are put in the prepared ditch and the seed cut off into 10 to 20 inch pieces which include at least two or three buds. After this, the seeds are covered with dirt.

Usually after 18 months the cane can be harvested the first time. The second harvest is after another 12 months, and the third harvest is made after 12 months from second harvesting. This procedure is usually used in the State of Sao Paulo. Some farmers harvest four or five times after first seeding, but these exceptional cases are not included in the present study.

Following planting mechanized cultivation is done two to three times, plus hand treatments done by simple labor. Before harvesting some special treatment is needed for ants and the sideroad of the sugarcane lot, which is used for harvesting, must be cleared.

The sugarcane harvesting period is from the end of May to October of the next year after the first planting of cane.

At the second harvesting, (i.e., first ratoon cane) the plants are treated with ant killers, fertilization, and by cultivation with mechanical cultivators which are used at least twice. Manual weed treatment is also used at least twice. This uses as much simple labor in the first harvesting. Furthermore, some sideroad cleaning and harvesting preparation work are necessary as at first harvesting.

The third time for harvesting (i.e., second ratoon cane) the cane is treated the same as the second harvesting treatment. Therefore, the input requirements are the same as the second harvesting of cane. However, the output will usually decrease considerably.

The usual harvesting method is a manual procedure that required a lot of simple labor. One adult can harvest around 2 tons a day by this manual method. Recently, many farmers have introduced a mechanical harvester which substitutes for simple labor. Unfortunately, I have no detailed data about this new activity.

Another labor-consuming activity is the loading process. After being harvested the fallen sugarcane is loaded onto a truck in order to transport it to the sugar mill. This loading process is usually manual, with one person loading 10 to 15 tons a day. However, today many farmers are introducing mechanical loaders that substitute for simple manual method. Again, unfortunately, data on this method are not available to me.

The production responsibility of sugarcane producers is in effect up to the entrance of the elevator of the sugar mill. This means production costs usually include all costs up to this state.

Even though we have identified our most labor-consuming operation such as the weed treatment, the harvesting operation and the loading operation in the sugarcane production process, we have no data at the present (17) except on the soil preparation method. Therefore, the impact of mechanical technology on the labor market will be studied in detail later in another research.

Sample, Sampling Technique, Organization of Questionnaire, and Collection of Data

Sampling

The present study uses one part of the total sample of sugarcane producers of the State of Sao Paulo, a sample that was made for the calculation of cost of production of this crop from 1969 to 1970. The author attached additional questions to this original questionnaire to get a technical coefficient for linear programming use. The sample is calculated for the entire State of Sao Paulo, dividing the state into three sugarcane producing regions. These regions are the Ribeirao Preto region, the Jau region, and the Piracicaba region. As we can see in Table 9 these three regions produce around 90% of the sugarcane of the State of Sao Paulo. Therefore, it was decided to take the sample from these three regions, especially considering the cost of travel to other faraway counties that produce less than 5% of the sugarcane total (see Figure 2).

Production region of sugarcane of the State of Sao Paulo

In the present study the region of Ribeirao Preto, the region of Jau and the region of Priacicaba are called regions 1, 2 and 3 respectively.

The region of Ribeiraro Preto (Region 1) includes the following counties:

Viradouro

Batatais

Table 9. Percentage distribution of sugarcane production by regions in the State of Sao Paulo (1969-70)[a]

Region[b]	Percentage			
	1968	1969	1970	Meama
Aracatuba	1.54	1.31	1.13	1.33
Jau (Bauru)	18.26	19.28	18.16	18.57
Piracicaba (Campinas)	37.03	32.15	32.75	33.98
Presidente Prudente	0.78	0.49	0.55	0.61
Ribeirao Preto	32.17	34.13	35.29	33.86
Sao Jose do Rio Preto	3.09	5.22	3.93	4.08
Sao Paulo	0.64	0.65	0.67	0.65
Sorocaba	4.92	5.50	6.47	5.63
Vale do Pariba	1.55	1.26	1.05	1.29
State Total	100.00	100.00	100.00	100.00

[a]Source: Estactica Agricola, I.E.A.

[b]Names in parentheses correspond to the division of Secretaria da Agricultura. However, the author changed the headquarters of the region for his operational convenience in the collection of data.

Figure 2, Map of the State of Sao Paulo, Brazil

Pontal

Jardinopolis

Bebedouro

Sertaozinho

Barrinha

Ribeirao Preto

Joboticabal

Guariba

Craninhos

Sao Simao

Araraquara

The region of Jau (Region 2) includes the following counties:

Rebeirao Bonito

Daurado

Brotas

Dois Corregos

Mineiros do Tietes

Jau

Macatuba

Areiopolis

S. Manuel

Lencois Paulista

Botucatu

Avare

The region of Piracicaba (Region 3) includes the following counties:

Pirassounuga

Sta Cruz da Conceicao

Leme

Araras

Rio claro

Mogimuirim

Sta Gertrudes

Cordeiropolis

Artur Nogueira

Santo Antonio de Posse

Iracemapolis

Charqueada

Aguas de S. Pedro

Sta. Barbara doest

Rio das Pedros

Sumare

Monte Mor

Capivari

Rafard

Elias Faust

Porto Feliz

Tiete

Piracicaba

The soil is generally very fertile in these regions although Region 1 has an especially fertile soil known as "rose land" (terra roxa). In general, a sugarcane production region has "Latosol" soil which is fertile also.

Population

The population is counted from the Institute of Sugar and Alcohol's maps of suppliers (I. A. A. do Mapa dos fornecedores).[3] From this list compiled by the I. A. A. we counted the total suppliers (fornecedores) of sugarcane as 9,422 farmers in 1968. These fornecedores[4] were stratified by size of production, which is decided by the quota system of the I. A. A. However, this stratification is arbitrary, with the expectation that the stratified sample effect will always gain (41).

The stratification by production size of the farm is shown in Table 10. Fewer than 500 tons is the first stratum; 501 to 1,000 tons is the second stratum; 1,001 to 1,500 tons is the third stratum; 1,501 to 2,000 tons is the fourth stratum; 2,001 to 3,000 tons is the fifth stratum; 3,001 to 5,000 tons is the sixth stratum; 5,0001 to 10,000 tons is the seventh and final stratum; the eighth includes farmers who produce more than 10,000 tons.

The distribution of the number of farmers is fairly skewed as we can see in Table 11. Almost 70% of the farmers belong to the stratum of

[3]This counting was done by the author and his secretaries.

[4]The Portuguese term fornecedor will be used for the supply farmer of sugarcane.

Table 10. Stratification of population by the size of production

Stratum number (strata)	Quantity of output (tons)
1	less than 500
2	501 - 1,000
3	1,001 - 1,500
4	1,501 - 2,000
5	2,001 - 3,000
6	3,001 - 5,000
7	5,001 -10,000
8	greater than 10,000

Table 11. Population of sugarcane farms and quantity of production in the State of Sao Paulo, 1968[a]

Strata	Tons	Farms[b] Number	Farms[b] Percent	Tons produced[c]	Percent
1	less than 500	4,496	47.7	1,267,132	8.6
2	501- 1,000	2,118	22.5	1,732,541	11.8
3	1,001- 1,500	875	9.3	1,236,693	8.4
4	1,501- 2,000	540	5.7	979,232	6.7
5	2,001- 3,000	519	5.5	1,497,482	10.2
6	3,001- 5,000	392	4.2	1,713,522	11.6
7	5,001-10,000	340	3.6	3,440,098	23.4
8	over 10,000	142	1.5	2,830,357	19.3
Total		9,422	100.0	14,697,057	100.0

[a]Source: I.A.A. maps of fornecedores 1967/1968.

[b]These stratification and number aggregations were made by the author in the Institute of Agricultural Economics.

[c]These quantity data are taken from the unpublished calculations of J. O. T. Ettori, Institute of Agricultural Economics, Sao Paulo.

less than 1,000 tons production. The farms producing above 1,001 tons make up only 30%. However, in quantity of production, these two strata produce only 20% of the total production of 14,697,057 tons.

The strata 6, 7 and 8 have less than 10% of the number of farms. However, these strata produce more than 50% of the total production.

Obviously stratification is necessary to reduce variance.

Region 1, Region 2 and Region 3 (Ribeirao Preto, Jau and Piracicaba, respectively), have the following populations: Region 1, 2,417 farms; Region 2, 1,508 farms; Region 3, 5,497 farms. The distribution of population by size and by region is shown in Table 12.

Characteristics of sugarcane production technology

The commonest classification of mechanical technology depends upon whether soil preparation is done by tractor or mule power. The former is frequently called the modern method and the latter the traditional method.[5] Furthermore, there is some mixture of the traditional and modern methods of soil preparation. However, the present study has selected only one region, i.e., Region 1 (Ribeirao Preto) for more detailed classification from the viewpoint of time and financial constraints. By post sampling classification the technological characteristics are divided into six categories of tractor type:

1. Tractor type I: 25-44 horsepower
2. Tractor type II: 45-69 horsepower

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[5]This classification is used by Secretaria da Agricultura, Sao Paulo, Brazil.

3. Tractor type III: greater than 70 horsepower

4. Mixed type 1 and 2 and called tractor type IV

5. Mixed type 2 and 3 and called tractor type V

6. Mixed type 1, 2 and 3 and called tractor type VI

In this region there are no traditional processes used. As we can see in Table 12, this region has a relatively greater number of farms which have greater sizes of sugarcane land.

Determination of sample size

The quantity of production was used to determine the variance of the total sampling number. This variance was calculated based upon our pilot research on the cost of production of sugarcane in 1967 which used the simple random sampling method (9). In this research we sampled around 80 farms from the whole state of Sao Paulo.

The following equation was used to determine the whole sample size of the state of Sao Paulo needed for the confidence level of 95% and a maximum acceptable error rate of 5%. A derivation of the formula is explained in Appendix A.

$$n \overset{>}{=} \frac{N \sum_{j=1}^{R} N_j T_j^2}{(N \varepsilon \bar{X}/z)^2 + \sum_{j=1}^{R} N_j T_j^2}$$

where n = the desired sample size

N = total population

Table 12. Population distribution and percentage of fornecedores stratified by region and by size, 1968[a]

	Size								Total
	0-100	501-1,000	1,001-1,500	1,501-2,000	2,001-3,000	3,001-5,000	5,001-10,000	+ 10,000	
Region I									
Population	891	528	284	169	179	157	156	53	2,417
Percent	20	20	32	31	34	40	46	41	26
Region 2									
Population	803	249	140	71	81	65	57	42	1,508
Percent	19	14	16	13	16	17	16	32	16
Region 3									
Population	2,802	1,341	451	300	259	170	127	47	5,497
Percent	61	66	52	56	50	43	38	24	58
Whole State									
Population	4,496	2,118	875	540	519	392	340	142	9,422
Percent	48	23	9	6	5	4	3	2	100

[a]Calculation made by author based upon the maps of fornecedores of I. A. A.

N_j = population of stratum j

T_j^2 = variance of stratum j, which is substituted for the sample variance of the pilot research of 1967

ε = acceptable error rate

z = confidence coefficient

$\overline{X}$ = an estimate of population mean obtained from the pilot research

R = number of stratum.

Substituting z and T_j^2 for the estimated means and variance of the 1967 research, and other parameters for the 1968 data that are codified by author, the total sample was calculated in the above equation as n equals 321. This figure was increased to 360 because it was possible that some questionnaires would not be usable. For further analysis, the total sample 360 was divided into various sizes of strata. For the allocation of the total sample into each stratum the method of proportional allocation was used.[6]

The following equation was used for the determination of sample allocation:

$$n_j = n \frac{N_j}{N} \quad (J = 1,2,\ldots,R)$$

where n_j = sample size of jth stratum

---

[6]The advantage and disadvantage of this will be found in Neguishi (30) or in Sukkatme (41) in further detail.

n = total sample of the State of Sao Paulo

N_j = jth stratum population

N = population

R = number of stratum.

Using the above equation the allocation of the sample size was made as in Table 13. The total sample was allocated among regions; Region 1 (Ribeirao Preto) (106); Region 2 (Jau) (60); and Region 3 (Piracicoba) (194). Furthermore, the size allocation was the highest number in stratum 1 (81) and the smallest number in stratum 8 (16).

Data collection

The data collection was the hardest work in this research and I had tremendous difficulties. At first I planned to complete data collection within six months with three other researchers of the Institute of Agricultural Economics. The beginning date of field data collection was December 1968. However, this initial plan was broken by the transferring of the researchers to other sections because our staff in Institute of Agricultural Economics was very small at that time in comparison to the quantities of research that we had to do. Therefore, I frequently had to dedicate my time to research other than the sugarcane project. Another serious problem was that our vehicles were in very poor condition; this prohibited a normal scheduling of the collection data. These problems were burdensome to me. When I completed the total desired sample of 360,

Table 13. Allocation of the sample farms by region and by size

	Size								
	1	2	3	4	5	6	7	8	Total
Region 1	16	14	16	15	17	12	9	7	106
Region 2	17	9	9	6	8	4	4	3	60
Region 3	48	44	32	27	21	9	7	6	194
Total	81	67	57	48	46	25	20	16	360

it was April, 1970. Out of 360 samples (questionnaires), almost 60%, i.e., more than 200, were completed by me.

Procedure of data collection

The first phase of data collection was to train other researchers to work with the questionnaires. To satisfy this objective I took them to farmers and showed them how to ask questions. The training period always took from one to one and one-half weeks. Since the researchers of the Institute of Agricultural Economics asked farmers directly in a detailed questionnaire, it took two to three hours for each farmer. Including travel time, a very skilled researcher could collect at most only four questionnaires per day. On the average, one researcher could collect approximately 2 to 3 questionnaires a day.

Unfortunately, the researchers of the Institue of Agricultural Economics are public servants. Therefore, they work only five days a week. This system is very inconvenient for research, since when the weekend nears the researchers plan to go back to home in the city, which is far from the fieldwork, and on Monday it takes too much time just to reach the working field, usually in interior of the state (as can be seen on the map of the State of Sao Paulo). This is an inefficient factor in this kind of research. In the future the Institute of Agricultural Economics should consider some alternative working methods for research officers.

These trained researchers drove one car with a team couple. One researcher went to one farmer while the other worked with a second farmer. When he completed his questionnaire, he then went to pick the other up. Sometimes the researchers needed to make an appointment with farmers for a time at their convenience; for example, in the evening or in the early morning.

In the county hotel which was a base in that region we had a meeting each night in order to clear up obscure points of the questionnaire. These meetings were very helpful in unifying the concepts of the questionnaire.

<u>Brief presentation of the questionnaire</u>

The principal objective of this questionnaire was to obtain a complete cost structure of the sugarcane industry in the State of Sao Paulo through the sampling method. However, I realized that if we modified our technique a little bit, then one could get more variable data for the linear programming application. Furthermore, the cost of the collection of data was not so different since we increased time only a half hour or so.

<u>The structure of the questionnaire</u>

The structure of the questionnaire is shown in this brief summary:

1. General information

This part included name of landowner, name of county, total farmland area, total sugarcane land area including a detailed description of sugarcane field, distance from farmland to municipality, distance from farmland to sugar mill, type of land, topography, variety of sugarcane planted on the farm and educational level of farm manager.

2. Labor

Included fixed family labor, wage level, hired labor working only for the cultivation of sugarcane and weeding treatment. (Fixed labor on year basis was included in the first section.)

The second part of labor included an operational labor description, which included cleaning new land or old sugarcane roots, harrowing, plowing, fertilizer distribution, ditching, selection of seed sugarcane, planting cane, cultivation by tractor, harvesting and so on. These operational descriptions were based on per alqueire (unit) of land area. Furthermore, in this part machinery and necessary quantities of animals were attached.

Yield information was divided into two parts: one, the most recent yield, i.e., 1968/1969; the other, the average yield for the last 3 years (which is used in the present study).

A questionnaire which tried to get biological technology, i.e., the relationship between variety and yield, was used also.

This information was obtained repeatedly until the second or third ratoon.

3. Harvesting operation

Included total output of the farm, cost of harvest per ton and average capacity of harvesting operation.

A loading operation included a cost of loading per ton, the quantity of load per person per day and type of loading information.

4. Transportation

Included type of transportation, i.e., owned or rented if rented, method used, how much it cost per ton. If owned vehicle is used, the cost of fuel consumption per trip to the sugar mill.

5. Variable costs

Included seed, fertilizer, herbicides and insecticides. This information is repeated until third ratoon.

6. Fuel consumption

7. Repair of machinery and equipment

8. General expenditures

Included taxes, electric power, telephone fees, general administration cost and special taxes for sugarcane operations.

9. Depreciation calculation

This part is divided into three sections: the first, animal and animal equipment inventories; the second, machinery inventories; and the third, building and installation inventories.

10. Type of usuage of land

If other crops were planted, then this section indicated that area. Moreover, the average price of land of this farm was described in this section.

This part included land contract conditions if the farm had any contract.

This information supplied the total necessary cost calculations. The cost calculation was used for the determination of the prices of sugarcane by the government in 1970.

CHAPTER IV. MODEL

In this study the demand for simple labor is defined simply as the relation between the prices and the quantities of simple labor demanded through a dynamic linear programming optimization procedure. Therefore, the demand for simple labor is defined within the dynamic linear programming framework.

Based on the fundamental assumptions of linear programming, such as linearity, additivity and divisibility, the demand function cannot be a smooth demand function. It will be a kind of step function which is derived from the assumptions.

The change of simple labor wage is Cr$0.0[1] to Cr$7.00 per day. This price range is based upon the average level of wage rates in the State of Sao Paulo, which was around Cr$3.80 per day in 1969.

The supply function for sugarcane is the relationship between its price and the quantity supplied. This supply concept is defined in the perfect competition market model, since in the imperfect competition market, the supply schedule cannot be define. In the State of Sao Paulo, the sugarcane fornecedor is considered to be almost perfect competition since farmers cannot interact with each other and neither can they influence the price of sugarcane. The established price of sugarcane is given to the fornecedor. The output of sugarcane is considered to be

[1]Cr$ is the Brazilian monetary unit. In 1969, the exchange rate was U. S. $1.00 equals Cr$4.20.

almost homogeneous. The number of fornecedores is not infinite, but 9,422 fornecedores are a sufficient number to be considered as a perfect competition model (10).

The price of sugarcane per ton has been changed from Cr$10.00 to Cr$25.00 around the price of 1969, i.e., Cr$18.01, in order to see the supply relation in this dynamic linear programming framework. The interval of parameter is Cr$5.00 except Cr$15.00 to Cr$20.00 the interval which the price of Cr$18.00.

Through this parametric approach, the impacts of direct change of output and indirect change of input (and especially the labor input) are observed through the dynamic linear programming framework.

Further, shadow price variations are important in order to examine the direction of the expansion of the farm firm.

Time Dimension

The time dimension in the present study is 12 years and it is dependent on the characteristics of sugarcane production. Generally, even though sugarcane farmers do not know the optimum combination of this crop, they use three different time dimensional methods. One method is 18-month sugarcane production. After harvesting the sugarcane, the farmer harrows the land for a new planting of cane. This procedure continues to repeat this method.

The second method is to use one more year of the first harvested sugarcane, i.e., first ratoon sugarcane, for the third year. After the final year's harvest, the land is turned over and the new sugarcane seed is planted. This procedure is repeated with a 3-year cycle.

The third method is to use one more year of the 2nd-year harvested sugarcane, i.e., 2nd ratoon sugarcane, for the 4th year. After the 4th year harvesting, this land is plowed by harrow and new sugarcane seed is planted. This procedure is repeated with a 4-year cycle.

These fundamental characteristics of sugarcane define the time dimension of linear programming. From the above three methods the time dimension of 12 years was chosen.

Special consideration on production cycle

After several computational calculations, it was found that initial years cannot use the whole land from the viewpoint of sugarcane cyclical restriction. This restriction confines the special land for the special period as in the above description. In order to sidestep this problem the model added the following activities beyond the original three activities: the first activities begin from the 2nd year; the second activities begin from the 3rd year; and the fourth activities begin from the 4th year. These detailed procedures are shown in Table 14 as (B), (C) and (D).

The reason for doing this is that the model can always have three planting activities except the final stage of 3 years, the 10th, 11th and 12th years. From this activity restriction the model can be divided into three parts: the beginning part that includes the first year to

Table 14. Sugarcane activity distribution over a 12-year period[a]

Activities	Years											
	1	2	3	4	5	6	7	8	9	10	11	12
1. P-H[a]	P	H	P	H	P	H	P	H	P	H	P	H
2. P-H-H	P	H	H	P	H	H	P	H	H	P	H	H
3. P-H-H-H	P	H	H	H	P	H	H	H	P	H	H	H
4. P-H		P	H	P	H	P	H	P	H	P	H	
5. P-H-H		P	H	H	P	H	H	P	H	H		
6. P-H-H-H		P	H	H	H	P	H	H	H			
7. P-H-H			P	H	H	P	H	H	P	H	H	
8. P-H-H-H			P	H	H	H	P	H	H	H		
9. P-H-H-H				P	H	H	H	P	H	H	H	

[a] P-H, P-H-H, and P-H-H-H show the activities that are planted in the first year and harvested in the second year, planted in the first year and harvested in the second and third year, and planted in the first year and harvested in the second, third and fourth years, respectively. (P=planting, H=harvesting)

3rd year; the intermediate part that includes from the 4th year to the 9th year; and the final part that includes from the 10th year to the 12th year.

Dynamic Linear Programming

General description of model

The basic assumptions of dynamic linear programming are the same as for linear programming except for the time concept. Using all basic linear programming assumptions, in addition to the time concept, the general structure of the dynamic programming is to maximize or to minimize some objective function subject to some constraints (8). The present study uses only the maximization method. Therefore, the following discussion is limited only in the maximization case. This description is shown more a detailed form as the following matrix form:

Maximize $X^t\ C^t$

Subject to

$$A^t X^t \leq B^t$$

$$X^t \geq 0$$

where

$$X^t = [x_j^t]$$

is the vector of production activity and j=1,2,...,n at time t

$C^t = [c^t]$ is the vector of cost activity and j=1,2,...,n at time t

$A^t = [x^t_{ij}]$ is the matrix of technical input-output coefficient i and j=1,2,...,m and 1,2,...,n at time t

$B^t = [b^t_i]$ is the vector of resources and transfer constraints i=1,2,...,m at time t

t = 1,2,...,s

This is a series of linear programming models (one for each time period t), each one of which influences another linear programming model. For example, the elements in any vector B^t are dependent upon the values obtained for the previous year. This is overlapped by the interyear coefficients. The remaining resources in the t-1th period could be transferred to the tth period.

The technical input-output coefficient can be expressed as the following matrix notation instead of the above expression:

$$A = \begin{bmatrix} A^1 & & & & & & & \\ & A^2 & & & & & & \\ & & \ddots & & & & & \\ & & & A^t & & & & \\ & & & & \ddots & & & \\ & & & & & & A^s \end{bmatrix}$$

where A is input-output overall technical coefficient of the dynamic linear programming matrix that is divided into A^t input-output technical coefficient matrix of tth year, t goes 1 to s. This divided matrix of the input-output technical coefficient has an interrelation with the other matrix by transfer activities.

The other vectors X and C are subdivided as the following subvectors:

$$X = [X^1, X^2,\ldots,X^t,\ldots,X^s]$$

and

$$C = [C^1, C^2,\ldots,C^t,\ldots,C^s]$$

where X and C are vectors of production level and cost of production in that production activity, $t=1,\ldots,s$ are time dimension from 1 to s. Since X vector corresponds to A matrix it has intertime relation also C is cost vector which is divided into $t=1,\ldots,s$ and this vector corresponds to A matrix, having intertime relation. These intertime relations are shown more clearly in Figure 3. All dashed boxes are intertime relation matrixes.

Again, as in linear programming, dynamic linear programming assumes that prices, yields and coefficients are known or may be determined for each of the future time periods. Determining the proper values to use in the model may be very difficult, but this difficulty is not peculiar to the dynamic linear programming framework. It is a problem facing any researcher doing research in future time periods. Another feature of dynamic linear programming is that even though the time concept is adapted

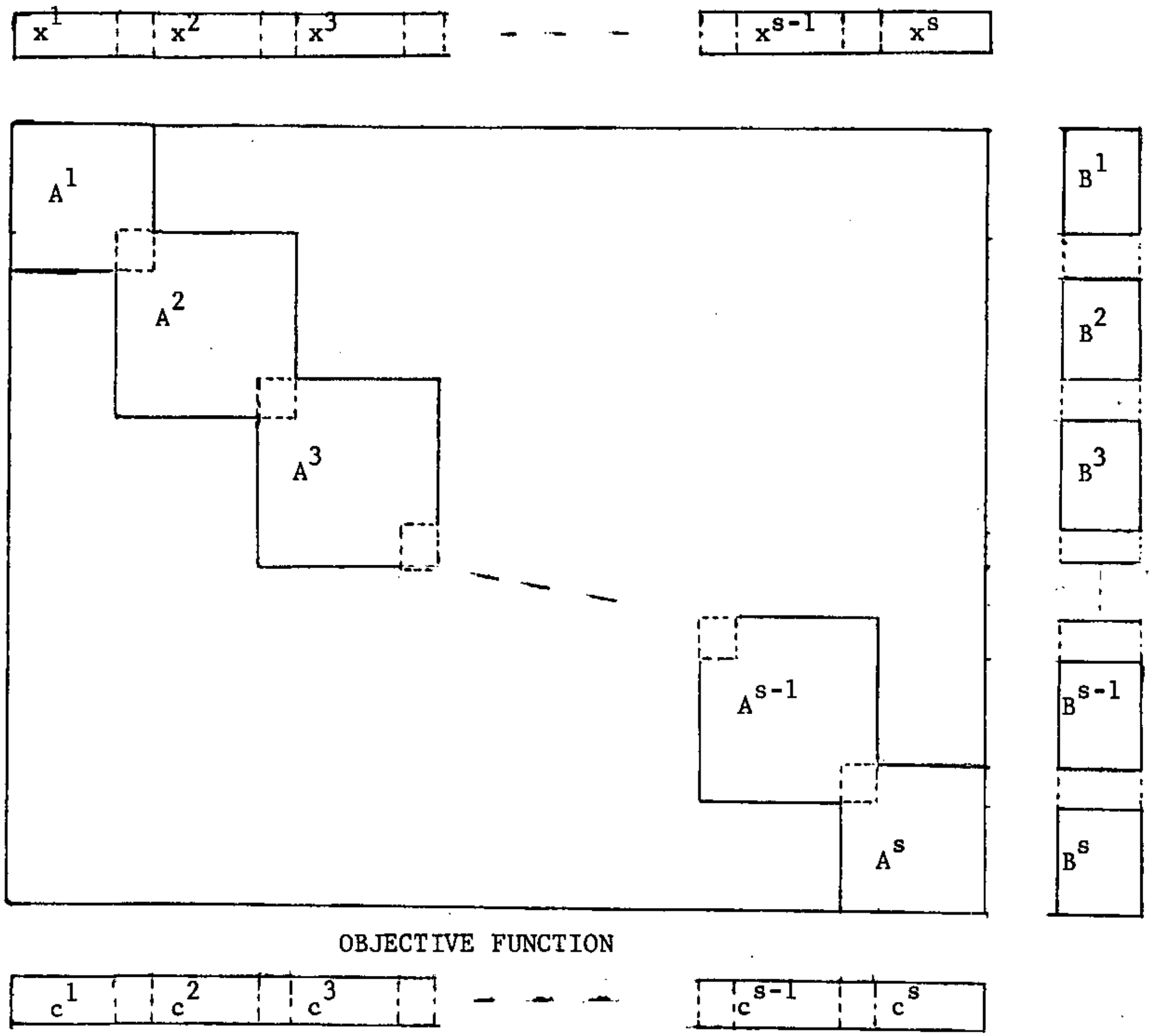

Figure 3. Structure of dynamic linear programming

in the dynamic linear programming to a linear programming, the dynamic linear programming optimizes the overall time period as if it were one single period of the linear programming model. Therefore, there exists a difference between the recursive method of the linear programming procedure and the dynamic linear program method in that the recursive linear programming determines the optimization on one period which is based upon previous optimum values, while the dynamic linear programming determines overall period optimization. A further explanation of this relationship might be expressed in the following equation using B vector at time t and t-1:

$$B^t = f[B^{t-1}, \bar{X}^{(t-1)}, I^t]$$

where

B^t = the tth period resource constraints

B^{t-1} = the t-1th period resource constraint

$\bar{X}^{t-1}$ = the t-1th period optimum variable

I^t = the tth period of external changes for the constraints

B, X are expressed by vector forms as before. This equation means that the tth constraint vector B is determined by the previous time period t-1th vector B, the previous time period t-1th optimum variable vector $\bar{X}$, and the tth period of external change vector I. I^t vector implies some special inheritances of resources, natural disasters, and the like.

The same concept is explained in the objective function as Hillier and Lieberman (16) and Swanson (42) do.

Choice of a Representative Farm Considering the Input-Output Coefficients

The choice of a representative farm for the present study was very difficult. Frequently, coefficients have to be chosen coefficients arbitrarily. However, in this study the distribution of mode of the input-output coefficients is considered as the basic criterion for the choice of a representative farm.

To choose a representative farm the hisogram was used for such key variables as labor coefficient, output per acre, and operational expenditures per unit of alqueire. These variables are identified as the important variables in the anterior study of the cost of production of these sampled farms (9) and (17).

Tractor type I Model

The tractor type I Model includes thirty farms which range from class I to class V in the quota system stratification. In terms of the production this ranges from 130 tons minimum to 2,400 tons maximum. All these farms use the tractor type I for their soil preparation processes. Eliminating some undesirable questionnaires such as those not having 3 years sequential productions and input coefficients, left only three farms for the final choice. These farms are I.B.M. numbers 18, 21 and 34.

Further, using the frequency figure and mode criterion I.B.M. number 18 farm has been chosen as the representative of this tractor type I farm.

The distribution of this tractor type I Model is 16 farms in class I, 8 farms in class II, 4 farms in class III, 1 farm in class IV and 1 farm in class V. Class I has the highest frequency, it can be noted.

In the present study even though the frequency distribution graph is not used to choose the representative farm by computer, it is recommended that a computer be used when selecting a representative farm in the future.

Tractor type II Model

The tractor type II Model has 49 farms in total. These farms produce from 600 tons minimum to 10,390 tons maximum. The stratification, according to the output classes, ranges from class II to class VIII. The distribution of the farm number in each class is 6 farms in class II, 12 farms in class III, 8 farms in class IV, 12 farms in class V, 4 farms in class VI, 6 farms in class VII, and 1 farm in class VIII. The highest frequency is in classes III and V, which have 12 farms. The tractor type II Model has the highest number of farms in this region, Ribeiraro Preto, Sao Paulo, Brazil.

To select the representative farm by this method, the same criterion as in the choice of the tractor type I is used. This criterion is the mode of the distribution of the input-output coefficients for four periods, especially heavy consideration being given to the labor input coefficients, the operational variable inputs and yield coefficients for three periods. After these considerations, I.B.M. number 66 farm has been chosen as the representative farm for this method of production. This farm belongs to class V, which has the highest frequency of the farms in this tractor type II Model.

Tractor type III Model

There was little difficulty in choosing the representative farm in the tractor type III Model because this model has only one farm which belongs to class VIII. The I.B.M. number 100 farm has only tractor type III.

Tractor type IV Model

To choose the representative farm of the tractor type IV Model the same criterions as in the choice of the representative farm of the tractor type I and II was used. The final choice of this representative farm is I.B.M. number 49 farm.

This model and the following two models are only combinations of the tractor type I Model, tractor type II Model and tractor type III Models in their input-output coefficients. However, the constraints are taken from the representative farms of each tractor type model for the construction of this type of model, such as the tractor type IV Model, the V and VI Models.

The tractor type IV Model has 9 farms in total, which range from class IV to class VII. The highest frequency is 3 in class V and in class VI. The production ranges from 1,900 tons to 8,700 tons per farm.

Tractor type V Model

The tractor type V Model has 11 farms that range from class V to class VII. The total production of these farms is from 2,550 tons to 64,050 tons per farm. To choose the representative farm the same criterion as before was used. The final choice for this model was I.B.M. number 101 farm.

As in the tractor type IV Model this model is the combination of the tractor type II Model and the tractor type III Model. For the construction of the model, the representative farm uses only the constraint coefficients that are taken from this farm.

Tractor type VI Model

The tractor type VI Model has a total of 6 farms. These farms consist of 3 in class IV, 2 in class VI, and 1 in class VIII. The total production ranges from 1,800 tons to 40,260 tons per farm. The same criterions were used as for previous models. The final choice was I.B.M. number 52 farm.

This model is constructed by the three models that are the tractor type I Model, the tractor type II Model, and the tractor type III Model.

For the construction of the tractor type VI Model the resource constraint coefficients are taken from this representative farm.

The distribution of the farms by size for each tractor type model, region, is shown in summary form, in Table 15. The highest number of farms are 49 farms in the tractor type II Model. The smallest number of farms is 7 in the tractor type III Model.

Application of Model to the Present Studies

The demand for simple labor in the sugarcane production region of Ribeiroa Preto, the State of Sao Paulo, Brazil, and the supply of sugarcane impacts on the simple labor market are analyzed over the quota policy system by using this dynamic linear programming model. This general model is applied to the six specific models according to tractor-power capacity and the combinations of tractor power capacity. Doing this diversification of the tractor-power capacity, this study analyzes mechanization impact on the simple labor market. From the former analyses of the cost of sugarcane production of the State of Sao Paulo, Brazil, we identified that the most important factors that influence the labor inputs mechanization and the use of chemical products for weed and ant treatment even though this cost of production analysis was an imperfect one in the sense of the quantity expression (9), (17).

These six specific models based upon tractor-power capacity are: a tractor type I Model in which tractor capacity is 25 to 44 horsepower, a tractor type II Model, in which tractor capacity is 45 to 69 horsepower,

Table 15. Distribution of the number of farms by size for each tractor type model in the sample, Region I.

Model	Classes								Total
	I	II	III	IV	V	VI	VII	VIII	
Tractor type I	16	8	4	1	1				30
Tractor type II		6	12	8	12	4	6	1	49
Tractor type III								1	1
Tractor type IV				2	3	3	1		9
Tractor type V					2	3	2	4	11
Tractor type VI				3		2		1	6
Total	16	14	16	15	17	12	9	7	106

a tractor type III Model in which tractor capacity is above 70 horsepower; a tractor type IV Model in which is a combination between a tractor type I and a tractor type II; a tractor type V Model which is a combination between a tractor type II and a tractor type III; and final tractor type VI Model which is a combination of all of three tractor types.

First, one of these models, tractor type II, was chosen independently in order to do a test run. In two test runs we found the problem of the resource restriction for the first ratoon sugarcane and second ratoon sugarcane because these ratoon sugarcanes occupied the same land for two, three and four years. Therefore, there is no flexible land use for these occupied lands. To solve this problem we added new planting activities to the original three activities at the 2nd, 3rd and 4th years as in Table 14. With this device the model always gets new planting activities. This was shown in the new run. In the original model we had farmland that was not used up completely until the 3rd year. But using this new device the farmland is fully used up from the 2nd year. These additional activities of sugarcane increased the number of basic activities to nine.

The tractor type I Model has 255 rows and 575 activities. The calculation time used for this model was 47 seconds including range analysis in order to get only an optimal solution by the I.B.M. 360 computer.

The rows are divided into land, labor, financial constraint rows and transfer rows.

In the first year the model has only 3 transfer rows. But, from the 2nd year on, the transfer rows increased to 7 and 9 at the 2nd and 3rd years respectively. From the 4th year to the 9th year these nine transfer rows are maintained. From the 10th year to the 12th year the number of transfer rows decreased to 8, 5 and zero respectively.

The column number is maintained over all years except the last year. The number of activities is 25 for each year; however, the twelfth year adds one more activity, which is an inventory activity.

The model is constructed by 4 crop activities, 13 sugarcane activities, 2 hired labor activities, 5 financial activities and capital transfer activity in over 12 years in each year.

The tractor type II Model and the tractor type III Model have the same structure as the tractor type I Model.

The tractor type IV Model is a combination of the tractor type I and the tractor type II. The combination increased the row numbers and the columns, because the transfer rows are doubled and the tractor-available constraint is added to each giving a year total of 12 rows. The activity of this model is increased because sugarcane activities are doubled by the addition of another type of tractor method in the tractor type IV Model. In short, there are 353 rows and 765 columns in total.

The tractor type V Model that is a combination of the tractor type II and the tractor type III has the same size structure of dynamic linear programming as the tractor type IV Model, i.e., a matrix of 353 x 765.

Table 16. The structure size of models

Model	Matrix Size
Tractor type I	255 x 575
Tractor type II	255 x 575
Tractor type III	255 x 575
Tractor type IV	353 x 765
Tractor type V	353 x 765
Tractor type VI	451 x 1,003

The tractor type VI Model that is a combination of the tractor type I, II and III, increases both rows and columns. The number of rows is increased naturally by the increased new transfer rows and restriction for the tractor-available day to the tractor type III, in addition to the tractor type V model. The activities of the tractor type VI model are increased in the quantities of the sugarcane activities of the tractor type III, in addition to the tractor type V Model. In short, the structure of this tractor type VI Model has a matrix of 451 x 1,003.

In Table 16 the size structures of all models are shown in summary form. Naturally the combination model has a larger matrix.

Quota System Policy Introduction into Dynamic Linear Programming

The quota of sugarcane production is determined by I.A.A., considering the last 3 to 4 years of the sugarcane farmers' production. To verify this quota system policy on the sugarcane farm optimization the bounding procedure is introduced into the basic dynamic linear programming model (3). This bounding restriction is based upon the stratification made in the sampling section.

The six tractor type models and the correspondent classes of production quotas are shown in Table 17. These bounds appear as shown in Table 17, with ranges of a lower limiting production to an upper limiting production. There are two classes which are doubled in the representative farms. The tractor type III Model and the tractor type

Table 17. Tractor type models and correspondent production quotas

Model	Class	Quota range (tons)	
		Lower	Upper
1. Tractor type I	II	501	1,000
2. Tractor type II	V	2,001	3,000
3. Tractor type III	VIII		+10,000[a]
4. Tractor type IV	IV	1,501	2,000
5. Tractor type V	VIII		+10,000[a]
6. Tractor type VI	IV	1,501	2,000

[a]More than 10,000 tons.

V Model belong to class VIII that should produce only above 10,000 tons sugarcane. Two other models, the tractor type IV Model and the tractor type VI Model are in class IV that ranges from 1,501 tons of sugarcane production at the lower bound to 2,000 tons of sugarcane production at the upper bound.

These bounds are inserted on the selling activity of sugarcane production of basic dynamic linear programming models in order to verify the impact of the quota system policy on the efficiency resource allocation.

Activity Construction

This section is divided into two parts: first, the construction of constraint figures and second, the construction of the activities for each tractor type model.

Construction of the constraint figures

The constraints are divided into land, labor and capital. Labor is further divided into two periods: the planting period and the harvesting period. Capital constraint is divided into the initial capital and the limitation of borrowing amount of capital. The constraints of the mule-available days, the tractor-available days and the initial capital available are taken from the specific farm chosen as the representative in the section of selection procedure. Considering a situation in which one farmer owns one tractor or one mule, he has constant available days. In the computation stage, it is rather difficult to get an average figure of the initial capital restriction. Therefore the specific farm figure is used. Naturally, in future research we must use consistent figures for the construction of constraint figures.

Land

The land restrictions are taken from the arithmetic mean of the each class of production stratification. These mean figures are used for the constraints of the representative farms. The following Table 18 shows the numerical figures. The land restrictions imply the tillable land.

Labor constraints

There are usually three kinds of labor in the sugarcane industry: owned family labor, hired fixed annual labor, and hired daily labor.

The owned family labor available is estimated for each class in the arithmetic mean. The unit of labor is the day, which is 8 hours work. One month is estimated at 25 available working days (33).

The family that has a child work force is counted as one full worker if this family has 2.5 children under 15 years. The female labor force is counted as 80% of one adult male labor force for the direct production activity. However, if the model considers the total equilibrium of the homestead, her work is naturally counted as 100%

Table 18. Mean tillable land and the number of farms by size

Class (size)	Unit	Mean tillable land	Number of farms
1. Less than 500 tons	Alqueire	15.03	16
2. 501 - 1,000 tons	Alqueire	23.34	14
3. 1,001 - 1,500 tons	Alqueire	33.9	16
4. 1,501 - 2,000 tons	Alqueire	48.08	15
5. 2,001 - 3,000 tons	Alqueire	47.03	17
6. 3,001 - 5,000 tons	Alqueire	70.04	12
7. 5,001 - 10,000 tons	Alqueire	117.00	9
8. Greater than 10,000 tons	Alqueire	456.85	7
Total			106

contribution for the model because of other than direct farm production activities, such as education of children, preparation of food and clothing, etc.

Secondly, the hired fixed annual labor force is used just as is t the family owned labor force. This labor is fixed and employed on an annual basis. These employed people usually live on the farm and not far from the landlord's residence. Frequently, they construct some community-like village on the greater farm. But on the small farm they live just like the landlord's family. Sometimes they are allowed to cultivate some special land--around 1 to 5 alqueires (2 to 10 hectares)--for raising foods for family consumption such as rice, horticulture, beans and the like. Therefore, the landlord may discount some percentage of their monthly salary.

Larger farms have some qualified laborers, such as tractor driver, bookkeeper, etc., who receive higher salaries than the simple hired laborer.

Finally, the hired daily labor, which is very important in the sugarcane industry, is hired temporarily on the basis of daily or monthly payment for seasonal work at harvest time, planting time, and weed-treatment time.

Period of the labor requirement

The peak of the usage of labor for sugarcane production is divided into two periods that show the constraints of labor: first, the period of planting and treatment of sugarcane, which ranges from

November to April; second, the period of harvesting, which covers the six months from May to October. These two periods are constraints and work as a strangulation on the labor force.

The determination of labor constraints is done by the arithmetical mean of each class considering two periods of the divi§ion as mention above. This result is shown in Table 19.

Hired labor constraint

This constraint is defined by the capital available. So the maximum amount of the hired labor constraint is obtained by dividing the total available amount of capital by the cost of the hired labor per day, i.e., 8 working hours for simple labor. (Simple labor means the laborer does not need an special training to get a certain skill, such as a special skill in administration or an understanding of mechanics. This kind of simple laborer works in plant treatment; weeding and cultivation, manual harvesting, and manual loading onto trucks.)

Capital

Capital is considered capital in hand as cash payment for daily labor payment, or operational cost for the tractor and the truck such as repairs and fuel. The input variable costs such as insecticide, fertilizer and various operational costs are included in the initial capital estimate, too. Furthermore, in dynamic linear programming, one-half the family income is considered proxy of the consumption expenditures for this capital category.

Table 19. Labor constraints for two periods in the arithmetic means by size

Class	Unit	Planting and treatment period	Harvesting period
1	Days	358	312
2	Days	308	598
3	Days	891	830
4	Days	966	1,250
5	Days	835	1,428
6	Days	1,696	2,083
7	Days	2,412	3,669
8	Days	12,613	11,182

The family labor cost is not included in this capital category. However, this kind of fixed cost is subtracted at the end of the year in order to get the net income figure, considering other fixed costs and depreciation for the invested capital.

Capital borrowing constraint

The Central Bank of Brazil fixed by law the maximum rate of interest for the individual farmers at the rate of 15% per annum. This rate of interest is divided into 7% for the real interest rate and 8% for the monetary correction that may be considered as an inflation rate. This rate of interest is very low compared to a private market rate of investment which ranges from 20% to 30%, sometimes arriving at around 40% per year. This low rate of interest was a decision of the government to promote the agricultural production necessary for the Brazilian economic development (32).

The limit of financial quantities for the individual farmer is defined by the same bank as fifty-times that of the minimum salary per month. This minimum salary per month varies from one farm to another. The present study used the quantity of minimum salary in this region at the level Cr$144.00. Therefore, the total financial limit of quantity is Cr$86,400.00.

Construction of activities

Specific characteristics of activities; crop activities (excepting sugarcane activities); and sugarcane activities by tractor type model are discussed in this section. Specific characteristics describe special characters of present dynamic linear programming: capital accumulation, lending activity, etc. Crop activities discuss four more activities in addition to sugarcane activities. Sugarcane activities are divided into the various tractor type models.

Preceding this is a discussion of prices.

Prices

The present study used average 1969-1970 prices of products, and of inputs for the sugarcane by the sampling questionnaires. The other commodity prices, such as cotton, corn and rice, are taken from the "Agricultura em Sao Paulo," harvest of minimum prices of 1969-1970.

The input prices of these other commodities are taken from the journal "Agricultura em Sao Paulo," 1966. To adjust the time lag of these input prices of other commodities the index number is used. Since it was not possible to find the base period price of 1948-1952 in this index, a procedure of calculus was used:

$$\frac{\text{Price of input}}{1970} = \frac{\text{Index number 1970}}{\text{Index number 1966}} \times \text{Price of input 1966}$$

The summary of commodity prices used in the present study is shown in Table 20.

The daily hired labor price varies from farm to farm. Therefore, the average of the regional daily wage is considered in addition to the minimum wage rate.

Input prices

All input prices are taken from the questionnaire for the cost of production for the sugarcane activities. But the other enterprises, cotton, corn and rice, used the input prices of (19).

The input prices for the sugarcane enterprise are shown in Appendix C. These names are not translated into English because here are many difficulties in the translation of these particular names.

Characteristics of activities

This section describes special characteristics of activities not included in the direct production activities, such as cotton, corn, rice and sugarcane.

Net revenue

The net revenue is defined as the difference between the gross revenue, that is, yield per alqueire, times the price of output and the cost of operating capital.[2] The present study assumes that the rate of change of output prices is the same rate of change of input price as well as a change rate direction, even though this does not reflect the "cost squeeze" in the agricultural sector. There is not enough data to get projected prices of yield and of input. Further, this net revenue is not discounted over time. Of course, we could use a discounted net revenue in future studies depending upon the computation fund availability.

[2]Alqueire is a unit of land area which corresponds to 2.42 ha.

Fixed costs

Fixed costs non-allocable to the operational costs include repair of the machinery and equipment, the general expenditures that include taxes (municipal and state), telephone fees, light and power, securities and the depreciation for the machinery equipment and buildings.

The interest on capital investment is not deducted, since this return is compared with market prices through shadow prices.

The return for the land is seen through the shadow prices. Therefore, neither is this return deducted from this fixed cost activity.

These fixed costs are not only for the sugarcane activity, but include all other activity costs on the farm. Therefore this cost is the total of farm expenditures on fixed costs except the family consumption or living cost.

The following Table 21 shows a fixed cost activity used in the model.

Net income accounting row for each year

The net income row is constructed in the same manner as the objective function that is separated into each year. The cost is shown by a negative sign and the income is shown by a positive sign. The result will be the same as the maximization of net income which is separated into each year. Table 22 shows this activity in an abbreviated form. The type of row, N, is the same as the objective function. The activity shows two activities, one of which is the first year which does not produce any income. The second year net income row shows a negative cost

Table 21. Fixed cost activity

Right hand side	Type of row	Activity	
		C row	Input-output cost
1	E	Fixed cost	1

Table 22. Net income accounting row for each year

Row name	Type of row	Activities		
		First year	Second year	
Objective function	N	-a	-b	b
First year net income row	N	-a	0	0
Second year net income row	N	0	-b	b

activity and a positive income activity which are added. The objective function is a net income for all years. The first year coefficient is indicated by a; the second year coefficient, by b.

Cash flow row

All costs, including operational and fixed, appear on this row as a negative input-output coefficient which is summed each year, showing the cash flow of that year. This activity is seen in Table 23.

Loan repayment

The cost of capital is included for the borrowing account of the same year. This cost must be repaid at the end of the same year. Therefore, it is assumed that this cost includes the cost of the whole year. Further, it is assumed that at the end of the same year this cost and the principal will have been paid completely, and the end of the same year and the beginning of the next year are continuous.

The capital accounting activity is attached to show the difference between the principal borrowed and the interest at the end of the year.

To see the above objectives clearly the activities are constructed in Table 24. The interest rate is 7% for the loan of Cr$1.00. There are three activities which are considered, i.e., a borrowing activity, and a repayment activity.

Table 23. Cash flow activity

Row name	Type of row	Activities			
		First year		Second year	
Objective function	N	-a	-a	-b	-b
First year cash flow	N	-a	-a		
Second year cash flow	N			-b	-b

Table 24. Loan repayment activities

Row name	Row type	Activities		
		Borrowing activity	Accounting activity	Repayment
Objective function	N	-.07		
Capital	L	-1.0		
Amount of capital borrowed	L	-1.07	-1	
Capital repayment	E		1	-1

Capital accumulation

The capital in the capital accumulation is the net income added into the next year's cash on hand. This quantity of capital accumulation can be verified by the transfer of capital from one period to the other, one unit of capital from tth year to t+1th year.

Capital lending

Capital is lent at a 6% interest rate which is returned at the beginning of the next year (see Table 25).

There is 1% difference between the rate of interest of the lending activity and the rate of interest of the borrowing activity.

Interest rate

As mentioned before the official bank interest rate is 7%, which is the cheapest borrowing rate since government subsidizes farmers through this lending procedure. In commercial banks the rate of interest is higher than this rate. However, we could change this rate of interest in the financial analysis.

Enterprises other than sugarcane

This section describes other crop enterprises: cotton, corn and rice. The corn enterprise is divided into two activities: animal power and tractor mechanical power.

The technical coefficients are based on (19); the prices are taken from the same journal. But they are changed by index number to get the

Table 25. Capital lending

Row name	Row type	Activity
Objective function	N	.06
tth year capital	L	1
t+1th year capital	L	-1.06

prices of 1969 (11). Since we did not have the technical coefficient of 1969 we assumed no technical change during these three years.

Cotton enterprise

The hired wage level per day, the material consumption (which includes fertilizer, insecticides and seeds), and the work animal operational cost are calculated by the index number (11). Using these basic data, input total operational costs are calculated in Table 26 in summary form. A detailed description of the technical coefficients is seen in (11).

The output of cotton per alqueire is 250 arrobas, on an average.[3] The price of cotton per arroba is Cr$9.55. Thus, the gross income per alqueire is Cr$2,462.50. The enterprise net income for this cotton activity is Cr$989.54, the difference between the gross income and the operational costs.

Corn enterprise

This enterprise is divided into two activities depending upon the method of the soil preparation. One activity is based upon animal power and the other upon tractor power. Usually, the method of animal power requires more labor days for the preparation of soil than does the method of tractor power.

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[a]Arroba corresponds to 15 kg.

Table 26. Input operational costs of cotton per alqueire (2.42 ha)

Item		Unit	Cost
1.	Labor	Cr$	688.22
2.	Tractor-fuel and oil	Cr$	74.24
3.	Animal	Cr$	14.24
4.	Fertilizer & insecticides	Cr$	696.26
	Total		1,472.96

The costs of operation per alqueire of the corn activity are adjusted by the index (11). These operational costs per alqueire are shown in Table 27.

The output of corn is 100 sacks per alqueire. Each sack weighs 60 kg. The price of each sack is Cr$9.00 as seen in the price list previously. Therefore, the gross income for both methods is Cr$900.00 per alqueire.

The net income for the animal power activity is Cr$227.09. But the net income for the tractor power activity is Cr$304.62. The difference obviously depends upon the operational costs as shown in Table 27.

Rice enterprise

The data for this enterprise are taken only by the animal cultivation method since, unfortunately, no other kind of data are available in the present study (19).

The operational costs are shown in Table 28 in summary form. The items of the operational costs are divided into labor cost, operational cost for animal and fertilizer insecticide and fumigant.

Production is estimated at an average of 75 sacks per alqueire, with each sack weighing 60 kg. The gross income is Cr$1,500.00, which is the result of the output quantity times the price per sack. The net income of this activity is Cr$629.37, which is the difference between the gross income and the operational costs.

In the State of Sao Paulo other enterprises are important in agricultural production. Unfortunately, adequate data for these are

Table 27. Input operational cost of corn per alqueire (2.42 ha)

Item	Unit	Cost	
		Animal	Tractor
Labor	Cr$	227.04	118.25
Operational cost for animal	Cr$	52.26	
Tractor fuel and oil	Cr$		83.52
Fertilizer, insecticides and needs	Cr$	393.61	393.61
Total		672.91	595.38

Table 28. Input operational cost of rice per alqueire (2.42 ha)

Item	Unit	Cost
Labor	Cr$	482.46
Operational cost for animal	Cr$	38.32
Fertilizer, insecticide and furmigant	Cr$	349.85
Total	Cr$	870.63

not obtainable in the United States for the construction of a dynamic linear programming framework. Generally, 21 principal agricultural enterprises are common in the State of Sao Paulo, and could be introduced in future research.

Sugarcane enterprise

The sugarcane enterprise is divided into six model types based upon the tractor power type and its combination. Construction of these models will be made by a one-to-one model based upon the questionnaire data. Here, activities of the linear programming framework correspond to the specific activity of the model. Sometimes the tractor type I Model is called Model I in abbreviation.

Tractor type I Model activity

This model is taken from I.B.M. number 18, the representative farm. As explained before, the constraints, land, labor and maximum capital borrowing quantities, are predetermined by averages. However, the initial capital available is taken from the specific questionnaire for the convenience of calculation.

The sugarcane activity is divided into various activities over time. The first-year activity includes a planting operation of sugarcane, a weed treatment and a cultivation operation. This first activity takes around 18 months. After the first period activity there comes the first harvesting activity which implies the cutting operation of sugarcane and the loading of the sugarcane for transport to the sugar mill.

After harvesting the 18-month sugarcane, the land needs a weed treatment and a cultivation operation in the second period before it is harvested. The duration of second period is 12 months.

The third period begins with harvesting activity, which there comes the same operation of treatment of weeds and cultivation as in the second period. This period takes 12 months again.

The fourth period is a repetition of the third period. However, this period has only the harvesting activity since this period is a final period. From this period on it is cyclical reptetion.

The model is divided into three activities: one-period activities; two-period activities; and three-period activities.

The input-output coefficients and the operational costs of this model are shown in Table 29 in summary form.

The input-output coefficient is taken per alqueire unit (2.42 ha). The net income shows only negative signs because they are all costs. The selling activity is separated independently. The production of output per alqueire decreases from 150 tons to 120 tons and then to 90 tons from the first harvest to the 2nd harvest and finally the 3rd harvest.

The operational costs are divided into four periods from those based upon the original models. The first period has the following cost items: fertilizers, seeds and insecticides, fuel and hired labor. In this Model

Table 29. Input-output coefficient and constraint of Model I

Item	Constraint	Unit	First period	Second period		Third period		Fourth period
			Planting	Harvesting	Treatment	Harvesting	Treatment	Harvesting
Land	23.34	Alqueire	1	1	1	1	1	1
Labor 11-4	308.00	Day	76.7		30.00		30.00	
Labor 5-10	595.00	Day		110		55.5		41.7
Tractor I	150.00	Day	6.7		1		1	
Mule	720.00	Day						
Initial capital	11,859.40	Cr$	786.76	528.00	492.08	266.40	492.08	200.16
Capital borrowing	86,400.00	Cr$						
Output		ton		150		120		90
Net income		Cr$	-786.76	-528.00	-492.08	-266.40	-492.08	-200.16

I, the hired labor for the sugarcane treatment is only for the weed treatment. Other operations of cultivation are done by the family labor. Since the second period is divided into two activities, (i.e., the harvesting activity and the treatment activity) accordingly the operational costs are divided into two activities, i.e., the operational cost for the harvesting and the operational costs for the treatment. The latter is subdivided into three items: fertilizer and insecticides, fuel and hired labor costs. The third period is the same as the second period except the harvesting cost is cheaper in the third year because of the reduced production. The fourth period has only the harvesting activity, which requires only harvesting operational cost since this period is the final period of the whole cycle of the sugarcane production. This is the complete structure of Model I of the sugarcane cost structure.

Initial capital for the tractor type I Model

Because the exact initial capital could not be obtained from the data of the questionnaire the initial capital is estimated by the following items: half of living cost; hired labor cost for the treatment of the sugarcane; hired labor cost for the cutting and the loading; input variable costs such as fertilizer, insecticides, fuel and repair cost.

Only half the whole living cost is incorporated, assuming that the farmer receives income from selling his products. So he needs average expenditures for the beginning of the year. Other items include the whole amount of variable expenditures.

The summary of these items is shown in Table 31.

Table 30. Operational cost of the Model I

Item	Unit	First Period	Second period		Third period		Fourth period
		Planting	Harvesting	Treatment	Harvesting	Treatment	Harvesting
First period							
Fertilizer, seed and Insecticides	Cr$	589.30					
Fuel	Cr$	53.46					
Hired labor cost	Cr$	144.00					
Second period							
Cutting and loading	Cr$		528.00				
Fertilizer, insecticides	Cr$			340.00			
Fuel	Cr$			7.98			
Hired labor cost	Cr$			144.00			
Third period							
Cutting and loading	Cr$				266.40		
Fertilizer, insecticides	Cr$					340.10	
Fuel	Cr$					7.98	
Hired labor costs	Cr$					144.00	
Fourth period							
Cutting and loading	Cr$						200.16

Table 31. Items of the estimated initial capital of the Model I

Item	Unit	Cost
1. Half of living cost	Cr$	1,142.00
2. Hired labor for the treatment of the sugarcane	Cr$	1,440.00
3. Hired labor cost for the cutting and loading	Cr$	4,437.00
4. Input variable costs	Cr$	3,899.40
5. Fuel	Cr$	391.00
6. Repair	Cr$	550.00
Total		11,859.00

Fixed costs of the tractor type I Model

The fixed costs (Table 32) of the tractor type I Model are composed of: repair for the machinery and the equipment, general expenditures, and depreciation of machinery and buildings. The sum of these costs is Cr$5,814.57.

Living costs in the tractor type I Model

The living cost of this model is estimated by the minimum salary since there are no data on this cost. On this farm two persons receive the minimum salary. Therefore, the total living cost of Cr$3,456.00 is estimated as:

2 persons x Cr$144.00 per month = Cr$288.00

Cr$288.00 x 12 months = Cr$3,456.00

The complete Model I is shown in detail in Appendix C as the computer output of MPSX.

Tractor type II Model activity

The model farm is I.B.M. number 66. This farm belongs to class V of the stratification of the quota system policy. The construction of this model is the same as the tractor type I Model shown above. However, all constraints, input-output and cost coefficients are different from Model I since this farm is different from the farm of Model I.

The difference is that Model II's tractor power is greater than that of Model I, from 45 horsepower to 69 horsepower, which consumes more fuel in comparison with the tractor of Model I.

Table 32. Fixed costs of the tractor type I Model

Item	Unit	Cost
1. Repair of the machinery and the equipment	Cr$	550.00
2. General expenditures	Cr$	1,155.40
3. Depreciation of machinery	Cr$	3,472.16
and of equipment	Cr$	637.01
Total	Cr$	5,814.57

The number of constraints is the same as in Model I. The row of tractor I is substituted for tractor II. So the result is the same constraint number as before.

The activities are divided into four periods over time as in Model I. The first period has only the planting and treatment operation. The second period involves two activities: harvesting activity and ratoon sugarcane treatment operation. The third period is the same operation as the second. The fourth period has only a harvesting activity since this period is the last period of the sugarcane cycle. The detailed input-output coefficients and the constraint coefficient of the tractor type II Model are shown in Table 33.

The input operational cost of the Model II is divided into four periods based upon the activity structure of this model. The coefficient of the input operational costs is shown in Table 34.

Initial capital of Model II

The estimation method used for the tractor type II Model is the same as the Model I. This estimate includes half the living costs, hired labor cost for the treatment of the sugarcane, hired labor cost for the cutting and loading, input variable costs, fuel and repair. These items, shown in Table 35, are used as proxy for the initial capital for this model.

Table 33. Input-output coefficient and constraint of Model II

Item	Constraint	Unit	First period	Second period		Third period		Fourth period
			Planting & treatment	Harvesting	Treatment	Harvesting	Treatment	Harvesting
Land	47.03	Alqueire	1	1	1	1	1	1
Labor 11-4	835.00	Day	49.5		26		26	
Labor 5-10	1,428.00	Day		84		54		48
Tractor II	200.00	Day	5.5		1		1	
Mule	520.00	Day						
Initial capital	41,989.70	Cr$	826.78	294.00	473.21	189.00	473.21	168.00
Capital borrowing	86,400.00	Cr$						
Output		ton		140		90		80
Net income		Cr$	-826.78	-294.00	-473.21	-189.00	-473.21	-168.00

Table 34. Operational cost of Model II

Item	Unit	First period	Second period		Third period		Fourth period
		Planting & treatment	Harvesting	Treatment	Harvesting	Treatment	Harvesting
First period							
Fertilizer, seed and insecticides	Cr$	698.10					
Fuel	Cr$	102.08					
Hired labor cost	Cr$	26.60					
Second period							
Cutting and loading	Cr$		294.00				
Fertilizer, insecticides	Cr$			395.50			
Fuel	Cr$			18.56			
Hired labor cost	Cr$			26.60			
Third period							
Cutting and loading	Cr$				189.00		
Fertilizer, insecticides	Cr$					395.50	
Fuel	Cr$					18.56	
Hired labor costs	Cr$					26.60	
Fourth period							
Cutting and loading	Cr$						168.00

Table 35. Items of the estimated initial capital of Model II

Item	Unit	Cost
1. Half of living cost	Cr$	1,142.00
2. Hired labor cost for the treatment of the sugarcane	Cr$	2,205.00
3. Hired labor cost for the cutting and loading	Cr$	12,865.00
4. Input variable costs[a]	Cr$	20,262.50
5. Fuel	Cr$	2,633.20
6. Repair	Cr$	2,880.00
Total	Cr$	41,987.70

[a]Input variable costs include fertilizer, insecticides, fumigant and herbicides.

Fixed costs on the tractor type II Model

Compared with Model I, one item is increased in the hired fixed labor cost, i.e., cost for the payment of the year-round fixed hired labor. Therefore, the fixed costs of this model are made up of four items as seen in Table 36.

Living costs of the tractor type II Model

The living costs of this model are estimated by the salary item of the questionnaire. It is estimated as Cr$2,284.00 for this model, based on the minimum salary of this region.

The complete model of the tractor type II is shown in Appendix C as the output of the BCDOUT of the MPSX.

Tractor type III Model activity

In this model the I.B.M. code number 100 farm was chosen as the representative farm. The organization of the structure of this Model III is the same as in Model I and Model II.

The constraint of the tractor type III is of course substituted for the other model tractor types. Generally, the coefficients of this model's constraints are larger than those of Model I or Model II because this farm model is larger.

The activities are divided into four periods as are the other two models. These coefficients of constraint and of input-output are shown in Table 37 in detail.

Table 36. Fixed costs of the tractor type II Model

Item	Unit	Cost
1. Repair of machinery and equipment	Cr$	2,880.00
2. General expenditures	Cr$	2,536.32
3. Depreciation of machinery, equipment and buildings	Cr$	11,068.09
4. Fixed labor cost	Cr$	8,107.68
Total		24,592.09

Table 37. Input-output coefficient and constraint of the Model III

Item	Constraint	Unit	First period	Second period		Third period		Fourth period
			Planting & treatment	Harvesting	Treatment	Harvesting	Treatment	Harvesting
Land	456.85	Alqueire	1	1	1	1	1	1
Labor 11-4	12,613.00	Day	30.29		10.00		10.00	
Labor 5-10	11,182.00	Day		69.3		56		43
Tractor III	1,200.00	Day	2.96		.5		.5	
Mule	1,440.00	Day						
Initial capital	331,113.58	Cr$	947.94	332.64	368.32	268.80	368.32	206.40
Capital borrowing	86,400.00	Cr$						
Output		ton		160		130		100
Net income		Cr$	-947.94	-332.64	-368.32	-268.80	-368.32	-206.40

The technical coefficient of the tractor is very small compared with other models. It is obvious that Model III uses a larger tractor for the soil preparation process. However, the fuel consumption is much greater than that of tractor type I or tractor type II.

The input operational costs have the four periods according to the structure of the activities of this Model III. The composition of the operational costs is shown in Table 38.

The cost of fuel is estimated from the item of the fuel consumption of the questionnaire which mixes all fuels including gasoline for other uses such as transportation.

The hired labor cost in the first period for the weed treatment is for 10 days. This farm could use a herbicide to reduce this labor cost. This model did not consider technical changes, but they are suggested for further research.

Initial capital of Model III

The estimation method used is the same as that of Model I and Model II. The composition of this estimation is half the living cost, the hired labor cost for the treatment of the sugarcane, the hired labor cost for the cutting and loading. Input variable costs are fuel and repair. In summary form these items are shown in Table 39.

Fixed costs of the tractor type III Model

The fixed costs of this Model III includes the repair of the machinery and the equipment, general expenditures, the depreciation of machinery equipment and buildings, and the fixed labor costs.

Table 38. Operational cost of Model III

Item	Unit	First period	Second period		Third period		Fourth period
		Planting & treatment	Harvesting	Treatment	Harvesting	Treatment	Harvesting
First period							
Fertilizer, seed and insecticides	Cr$	779.68					
Fuel	Cr$	120.26					
Hired labor cost	Cr$	48.00					
Second period							
Cutting and loading	Cr$		332.64				
Fertilizer, insecticides	Cr$			300.00			
Fuel	Cr$			20.32			
Hired labor cost	Cr$			48.00			
Third period							
Cutting and loading	Cr$				268.80		
Fertilizer, insecticides	Cr$					300.00	
Fuel	Cr$					20.32	
Hired labor costs	Cr$					48.00	
Fourth period							
Cutting and loading	Cr$						206.40

Table 39. Items of the estimated initial capital of Model III

Item	Unit	Cost
1. Half of living cost	Cr$	1,728.00
2. Hired labor cost for the treatment of the sugarcane	Cr$	26,400.00
3. Hired labor cost for the cutting and loading	Cr$	71,520.00
4. Input variable costs	Cr$	162,553.40
5. Fuel	Cr$	25,012.18
6. Repair	Cr$	43,900.00
Total	Cr$	331,113.58

This farm has 27 workers who work on the farm year-round whose salaries are included in the fixed cost categories. All items are shown in Table 40.

Living costs of the tractor type III Model

The living cost of this model is estimated by the minimum salary of this region. This farm is owned by two persons, so the living cost is Cr$3,456.00.

The present study does not use any assumption about the higher the income, the more a person consumes. In future studies this kind of assumption should, of course, be introduced.

The complete model of the tractor type III Model is shown in Appendix C in the form of the BCDOUT of the MPSX.

Tractor type IV Model activity

The tractor type IV Model is the combination of the tractor type I and the tractor type II. This combination is used only in the sugarcane activities but not in the other enterprises such as cotton, corn and rice, which remain as before.

In order to construct the constraints, fixed costs, the I.B.M. farm number 49 was chosen as the representative farm. This farm belongs to class IV. On the right-hand side, the tractor row is doubled into the tractor type I and the tractor type II. Furthermore, the transfer rows are doubled because the sugarcane activity is doubled. Other rows remain as before except for changes of the coefficients which are taken from this farm and the average values of the classes.

Table 40. Fixed costs of the tractor type III model

Item	Unit	Cost
1. Repair of machinery and equipment	Cr$	43,900.00
2. General expenditures	Cr$	3,398.70
3. Depreciation of machinery, equipment and of buildings	Cr$	124,057.72
4. Fixed labor cost	Cr$	46,656.00
Total	Cr$	170,713.72

The activities of the cotton, the corn and the rice enterprises remain the same as before, without any changes of their input-output coefficients. The fixed-cost reduction activity and the living-cost activity are the same activities as before with change of the input-output coefficients, which correspond to this class of farm. The other financial activities remain exactly the same as in the three anterior models.

The sugarcane activities continue to have the four same periods. The number of the activities and the input-output coefficients of each model, i.e., Model I and Model II, remain the same for this new model, Model IV. The sugarcane activities of Model I and of Model II are added in the new structure of Model IV. Therefore, the number of activities of the sugarcane doubled.

Initial capital of Model IV

The initial capital of the Model IV--the combination of the tractor type I and of the tractor type II--is compared of the following items summarized in Table 41. The estimation method is the same as before.

Fixed costs of the tractor type IV Model

Since this farm has two tractors, i.e., the tractor type I and the tractor type II, the fixed costs are very high compared to the other farms of this class that do not have two tractors. This farm does not have the laborers that stay year-round on the farm. Therefore, the fixed cost items of this model are reduced to three in the following Table 42.

Table 41. Items of the estimated initial capital of Model IV

Item	Unit	Cost
1. Half of living cost	Cr$	1,440.00
2. Hired labor cost for the treatment of the sugarcane	Cr$	3,360.40
3. Hired labor cost for the cutting and loading	Cr$	5,464.80
4. Input variable costs	Cr$	12,311.28
5. Fuel	Cr$	5,019.52
6. Repair	Cr$	4,002.00
Total	Cr$	31,597.60

Table 42. Fixed costs of the tractor type IV Model

Item	Unit	Cost
1. Repair of machinery and equipment	Cr$	4,002.00
2. General expenditures	Cr$	4,544.80
3. Depreciation of machinery, equipment and buildings	Cr$	14,490.65
Total	Cr$	23,037.45

Living cost of the tractor type IV Model

This cost is estimated by the regional minimum salary for this farm model. This farm has two persons who work as owners. So the total living cost is Cr$2,880.00 with Cr$120.00 per month.

The complete Model IV is seen in Appendix C as the output of the computer.

Tractor type V Model activity

The representative farm of this model is I.B.M. number 101, which belongs to class VIII and is fairly large. The tractor type V Model is composed of the tractor type II Model and the tractor type III Model.

The constraints are taken from the questionnaire of the specific farm, except for the constraint of land and of labor. This farm has two types of tractors--tractor type II and tractor type III. The tractor type III row is added to the original tractor type II model. The number of transfer rows is the same as the tractor Model IV.

The activities of the enterprises such as cotton, corn, and rice remain as before. The sugarcane activities are the same as in Model IV. Further, the input-output coefficients of the sugarcane of this model are the same as those of Model II and Model III. The number of sugarcane activities is doubled over the first three models. The periods of this model are divided into the four used previously.

The activity of the fixed cost and of the living cost are estimated from the data of the farm I.B.M. number 101.

Initial capital of Model V

The initial capital of the Model V is estimated by the questionnaire data since we do not have the exact data. The following items are added to find a proxy for the initial capital of Model V: half of living cost; hired labor cost for the treatment of the sugarcane, hired labor cost for the cutting and loading, input variable costs, fuel and repair. The figures for these items are shown in Table 43.

The salary for this farmer is equivalent to the minimum salary of an agronomist.[3]

Fixed costs of the tractor type V Model

On this farm, the fixed costs of the tractor type V Model is divided into three items: repair for machinery and equipment, general expenditure and depreciation of the machinery and of the buildings.

The figures of this model are shown in the following Table 44.

Living cost of the tractor type V Model

This cost is based upon the minimum salary for the agronomist since the owner of this farm is an agronomist. This criterion is taken from the research of the cost of production. Thus the year-round living cost is estimated at Cr$12.000.00.

The complete model V is shown in Appendix C as the output of BCDOUT of MPSX.

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[3]An agronomist has usually 15 years formal training.

Table 43. Items of the estimated initial capital of Model V

Item	Unit	Cost
1. Half of living cost	Cr$	6,000.00
2. Hired labor cost for the treatment of the sugarcane	Cr$	112,500.00
3. Hired labor cost for the cutting and loading	Cr$	120,745.00
4. Input variable costs	Cr$	128,043.60
5. Fuel	Cr$	31,967.40
6. Repair	Cr$	29,756.00
Total		429,012.00

Table 44. Fixed costs of the tractor type V Model

Item	Unit	Cost
1. Repair of machinery and equipment	Cr$	29,756.00
2. General expenditures	Cr$	46,790.00
3. Depreciation of machinery, equipment and buildings	Cr$	122,614.21
Total	Cr$	199,160.21

Tractor type VI Model activity

Model VI is constructed by the original sugarcane activities of Model I, Model II and Model III. In addition to the sugarcane activities it has cotton, corn and rice, which remain without any changes. The fixed cost activity and the living cost activity are changed in those input-output coefficients. I.B.M. number 52 farm was chosen as the representative of this model. This farm belongs to class IV.

The tractor-type rows are increased to three: tractor type I, tractor type II, and tractor type III. The transfer rows are two times greater than the original one-tractor type model.

The period of activities is the same as in any previous model. This model added only two other tractor type activities of the sugarcane exploration. By doing this the structure of dynamic linear programming will produce a more competitive situation.

Initial capital of Model VI

The initial capital of Model VI has the same following items (Table 45): half the living cost, hired labor cost for the treatment of the sugarcane, hired labor cost for the cutting and loading, input variable costs, fuel and repair.

Table 45. Items of the estimated initial capital of the Model VI

Item	Unit	Cost
1. Half of living cost	Cr$	2,052.00
2. Hired labor cost for the treatment of the sugarcane	Cr$	5,506.20
3. Hired labor cost for the cutting and loading	Cr$	4,450.50
4. Input variable costs	Cr$	6,167.50
5. Fuel	Cr$	1,074.75
6. Repair	Cr$	850.00
Total		19,250.95

Fixed costs of the tractor type VI Model

This representative farm has three different types of tractors. Therefore, the quantity of the fixed cost is not so great as the tractor type V Table 46.

Living costs of the tractor type VI Model

The living costs of this model is estimated on the basis of year-round salary paid for two persons since this farm has two persons working as the fixed labor supplier. The estimated figure is Cr$4,104.00.

Aggregation Procedure

The aggregation method is somewhat unsatisfactory in the present study (40). However, the following procedure has been used within the limited time and the costs of computation.

The total population of the Ribeirão Preto region, i.e., Region 1, in the cost of production analysis is divided into the models that have been defined previously according to the percentage distribution of the sample. Further, the number of farms is multiplied into the result of the computation of the representative farm of that model. After obtaining this total production of the model, the output could be distributed into each class according to the percentage distribution of the sample. This procedure is shown in Figure 4. Further, the percentage distribution is shown in Table 47, based upon Table 12.

The highest percentage of the tractor type model is the tractor type II Model, with 46%. The second highest percentage is the tractor

Table 46. Fixed costs of the tractor type VI Model

Item	Unit	Cost
1. Repair of machinery and equipment	Cr$	850.00
2. General expenditures	Cr$	1,949.00
3. Depreciation of machinery, equipment and buildings	Cr$	18,872.15
Total		21,671.15

Table 47. Distribution of the number of farms by size for each tractor type model in sample and in population

Model	Classes								Total		
	I	II	III	IV	V	VI	VII	VIII	Sample	Percentage	Population
Tractor type I											
Sample	16	8	4	1	1				30	28	677
Percentage	53	27	14	3	3						
Tractor type II											
Sample		6	12	8	12	4	6	1	49	46	1,112
Percentage		12	24	17	24	9	12	2			
Tractor type III											
Sample								1	1	2	48
Percentage								100			
Tractor type IV											
Sample				2	3	3	1		9	8	193
Percentage				23	35	33	11				
Tractor type V											
Sample					2	3	2	4	11	10	242
Percentage					18	28	18	36			
Tractor type VI											
Sample				3		2		1	6	6	145
Percentage				50		33		17			
Total											
Sample	16	14	16	15	17	12	9	7	106	100	2,417
Percentage											

Region	Model	Class (size)
Region 1 Ribeiron Preto	Tractor type I	Class I to class V
	Tractor type II	Class II to class VII
	Tractor type III	Class VIII
	Tractor type IV	Class IV to class VII
	Tractor type V	Class V to class VIII
	Tractor type VI	Class IV, class VI, and class VIII

Figure 4. Method of aggregation

type I Model with 28%. The smallest percent in the number of farms is the tractor type III Model. The population number of these type models are 1, 112, 677 and 48 farms, respectively.

The combination tractor types tractor type IV, V, and VI, are 8, 10, 6% with population numbers of 193, 242 and 145 farms, respectively.

Computation

The computation was done in the following order:

1. Standard computation,
2. Without lending activity,
3. Restriction on the lending activity,
4. Parametric procedure on labor costs,
5. Parametric procedure on the output price of the sugarcane,
6. Bounded procedure.

These six computations were done for each model. The lending activity which is an extraordinarily profitable model is calculated without lending activity and some parametric procedure in the lending activity constraints.

The parametric procedure on the labor costs has been done 8 times for each price change. The price change of the model, i.e., the activity change of the labor costs, was prepared by the FORTRAN IV method before the calculation was done by MPSX. The parametric procedure for the output prices of the sugarcane was done by the same procedure as the parametric procedure for the labor costs.

The bounded procedure was used for the selling activity for each year. When the parametric procedure is repeated, the bounded procedure is also repeated.

The following prices for the input hired labor costs of the parametric procedure are used: Cr$.00, Cr$2.00, Cr$3.00, Cr$3.50, Cr$4.00, Cr$5.00, Cr$6.00, Cr$7.00. These price ranges are chosen arbitrarily, based upon the arithmetic mean of the wage rate of this region, from Cr$3.50 to Cr$4.00. Through this computation the present study tries to see the demand for the simple labor through the dynamic linear programming structure.

The prices of the output of the sugarcane are changed for its parametric procedure of the dynamic programming to compute the supply of the sugarcane as the following figures: Cr$10.00, Cr$15.00, Cr$18.00, Cr$20.00 and Cr$25.00. These price changes are based on the price of the sugarcane of 1969/1970.

CHAPTER V. RESULTS AND ANALYSES

This chapter describes the results of the models constructed and computed in previous sections and interprets and analyzes these results.

The first part presents the standard efficiency optimum results. The second part examines the results of the quota system policy. Finally, these two parts are compared.

Interpretations of the sugarcane activities should be made cautiously since the model assumes the beginning years of a sugarcane operation. In the intermediate stage, the farmer is also in the intermediate stage of the sugarcane production. The final years show that the farmer is trying to close the sugarcane activity. These stages are divided by years. The first stage is from year 1 to year 4. The second stage is from year 5 to year 8, and the final stage is from year 9 to year 12. The reader should keep clearly in mind the above stages distinctions in the following description.

Each part involves the following divisions: standard presentation for each type of tractor model, labor demand for each type of tractor, and supply of sugarcane for each type of tractor. Additional discussions are introduced occasionally.

Standard Results and Analyses

Only the results and analyses of the standard model are discussed; other modifications are presented later.

Tractor type I Model

This model uses the tractor type I, with 25 to 44 horsepower. This classification was made primarily by the soil preparation method as mentioned above.

The objective function uses a net income concept not discounted over time. Initially a comparison of the undiscounted objective function result with the discounted objective function result was planned. However, the computer fund limited the latter computation. Therefore, this study presents only the undiscounted result. Further, this objective function subtracts internally such fixed costs as depreciations, taxes and fixed repair for machinery and buildings and a consumption allowance.

Over the 12-year period studied the objective function is Cr$91,825.55. This is the result of the optimal solution of this model. Further presentation of results of this model is divided into the sugarcane activities, crop activities, labor activities, financial activities including net income and cash flow for each year, and shadow prices.

Unfortunately, the demand function for the hired labor and the supply function impact on the absorption of the hired labor through this dynamic linear programming model will not be presented in this result. The time and budget constraints for the author, who has limited leave permission in the U. S., prevented this. However, these other results will be presented in the near future in a paper in Brazil.

Sugarcane activities

The unit of sugarcane activities uses an alqueire, which is equal to 2.42 hectares in metric measure. Therefore, the results are shown in alqueire as in Table 48.

A total of nine activities are in this model. The first three activities are plantings in the first year. These three activities are divided into two-period activites, three-period activities, and four-period activities; i.e., the first period plants sugarcane and the 2nd period harvests the sugarcane and the first period plants sugarcane, and 2nd and 3rd periods harvest the sugarcane, and finally the first period plants the sugarcane, and, the 2nd, 3rd and 4th periods harvest the sugarcane. The subscript characters B, C and D in Table 48 indicate whether the sugarcane is planted in the 2nd, 3rd, or 4th period respectively, according to the model construction in the previous chapter.

In the first year, two activities, the cane-harvest-harvest activity and the cane-harvest-harvest-harvest activity are entered in the solution at the level of 12.38 alqueires and of 2.59 alqueires respectively. The total area of the sugarcane is 14.97 alqueires, which is more than 50% of the total arable land, 23.34 alqueires.

The cane-harvest-harvest activity continues to occupy 12.38 alqueires over 3 years and the cane-harvest-harvest-harvest activity goes until the 4th year, continuing to occupy the same quantity of the arable land. In the 2nd year the area occupied by the sugarcane activities is the same as in the first year. However, in the 3rd year, the

Table 48. Area of sugarcane--tractor type I Model[a]

Year	Unit	Cane-harvest	Cane-harvest-harvest	Cane-harvest-harvest-harvest	Cane-harvest (B)	Cane-harvest-harvest (B)	Cane-harvest-harvest-harvest (B)	Cane-harvest (C)	Cane-harvest-harvest-harvest (C)	Cane-harvest-harvest-harvest (D)	Total of cane area	% of total area in cane	Output of sugarcane: Unit	Output of sugarcane: Total output
1	Alqueire		12.38	2.59							14.97	64	ton	
2	Alqueire		12.38	2.59							14.97	64	ton	2,245
3	Alqueire		12.38	2.59				8.37			23.34	100	ton	1,796
4	Alqueire			2.59				8.37		4.02	14.98	64	ton	2,492
5	Alqueire			4.04						4.02	8.06	35	ton	602
6	Alqueire			4.04			15.29			4.02	23.35	100	ton	1,087
7	Alqueire			4.04			15.29				23.35	100	ton	3,139
8	Alqueire			4.04			15.29				19.33	83	ton	2,197
9	Alqueire			6.80			15.29				22.09	95	ton	1,376
10	Alqueire			6.80							6.80	29	ton	1,019
11	Alqueire			6.80							6.80	29	ton	815
12	Alqueire			6.80							6.80	29	ton	611
Total														17,379

a(B), (C) and (D) first planted in the 2nd, 3rd and 4th years, respectively.

cane-harvest-harvest 8.37 alqueires of sugarcane are planted. Therefore, the total arable land of this year is used only in the sugarcane enterprise until its limit of 23.34 alqueires. The total arable land area is used for the sugarcane production in the 6th and 7th years. In Table 48 these figures are shown as 23.35 alqueires. The difference between 23.34 and 23.35 alqueires comes from the rounding error of the computations. These small differences do not influence the interpretation of the results. In the 4th year, the new sugarcane activity of the cane-harvest-harvest-harvest is planted at the level of 4.02 alqueires. The total area planted in sugarcane is 14.98 alqueires which, is equivalent to the first year and the 2nd year sugarcane areas. This activity continues to occupy the arable land until the 7th year at the level of 4.02 alqueires.

In the 6th year, the cane-harvest-harvest-harvest activity (B) is entered at the level of 15.29 alqueires which is maintained until the 9th year.

In the 9th year, the cane-harvest-harvest-harvest activity is planted at the level of 6.80 alqueires which is succeeded at the increased level of 2.76 alqueires. This activity continues to occupy the land area until the 12th year. This unique cane-harvest-harvest-harvest activity is entered in the solution at the level of 2.59 alqueires in the first 4-year cycle, at the level of 4.04 alqueires in the 2nd 4-year cycle, and at the level of 6.80 alqueires in the 3rd 4-year cycle.

In the 8th and 9th years, the total area occupied by the sugarcane is 19.33 alqueires and 22.09 alqueires, respectively. From the 10th to

12th years the total sugarcane area is only 6.80 alqueires which is 29% of the total area in sugarcane.

The total production of sugarcane varies over time. The maximum quantity of output is 3,139 tons in the 7th year, and the minimum quantity of output is 602 tons in the 5th year. These detailed productions are shown in the last column of Table 48.

Crop activities

In the crop activities only cotton entered into the optimum solution through 12 years, excluding the 3rd, 6th and 7th years. These 3 years completely occupy the entire arable land of the farm with the sugarcane activities. The highest quantity from the cotton-planted area is 16.54 alqueires in the 10th, 11th and 12th years, which are equivalent to 71% of the total available arable land. In the 9th year the cotton occupied only 1.25 alqueires, which is equivalent to 5% of the total arable land of the farm. In the first, 2nd and 4th years the same quantity of arable land (8.37 alqueires) is occupied by the cotton activity. In the 5th year and in the 8th year, the planted cotton areas were 15.29 and 4.02 alqueires respectively.

In all of the crop activities cotton is the most profitable in this model.

The summary form of these results is shown in Table 49.

Table 49. Area of crop land--tractor type I Model

Year	Unit	Cotton	Corn-animal	Corn-tractor	Rice	Total crop land	% of total areas in crop
1	Alqueire	8.37				8.37	36
2	Alqueire	8.37				8.37	36
3	Alqueire						
4	Alqueire	8.37				8.37	36
5	Alqueire	15.29				15.29	65
6	Alqueire						
7	Alqueire						
8	Alqueire	4.02				4.02	17
9	Alqueire	1.25				1.25	5
10	Alqueire	16.54				16.54	71
11	Alqueire	16.54				16.54	71
12	Alqueire	16.54				16.54	71

Hired labor activities

The labor activity is divided into two activities: planting, weed treatment and cultivation period activity; and harvest period activity. These labor activities show the necessary quantity of labor that comes from outside the farm. The model assumes that the supply of this kind of simple labor has no limit. So if the model requires the amount of labor necessary for the farm, the labor will be supplied without any restriction until the capital limit is reached.

In the planting, weed treatment and cultivation period--November to April--the 4th year does not require any outside labor. The greatest need for outside farm labor is in the first year, in which the number of necessary days is 1,342. Further, in the first year there is no harvesting activity in the sugarcane enterprise to consume most of the simple outside labor. The cotton activity in this period requires only 209 days, which is lower than the restriction of 598 days of this farm's available labor for the period from May to October.

In the May to October period the maximum consumption of outside labor is in the 7th year, a total labor of 1,475 days.

In summary form, these labor requirements are shown in Table 50.

According to the model construction, if we assume that one person has 25 working days per month, each period of the available working days is computed into 150 days for each person. The figure of the number of persons is estimated by dividing the total days absorbed in the period by 150 working days. These figures are shown in Table 50, comparing the total absorbed days in the same period.

Table 50. Hired labor activities--tractor type I Model

Year	Labor, November to April		Labor, May to October		Total hired labor/year	
	Day	Number of persons hired	Day	Number of persons hired	Day	Number of persons hired
1	1,342	8.9			1,342	
2	643	4.0	1,258	8.4	1,901	
3	411	2.7	232	1.5	643	
4			894	5.9	894	
5	1,039	6.9	226	1.5	1,265	
6	1,106	7.3	69	.5	1,175	
7	272	1.8	1,475	9.8	1,747	
8	391	2.6	519	3.4	910	
9	289	1.9	71	.5	360	
10	888	5.9	563	3.7	1,451	
11	888	5.9	193	1.3	1,081	
12	684	4.5	99	.7	783	
Total	7,953		5,599		13,552	

In the labor column, November to April, the highest number of workers employed constantly is shown in the first year. But in the labor column, May to October, the highest number of hired workers is almost 10 in the 7th year.

<u>Financial activities and net income and cash flow for each year</u>

The financial activities include three activities: capital borrowing, capital lending and capital transfer. In the solution this model has borrowed Cr $18,689.77 and Cr $16,277.99 in the 1st and 2nd years, respectively. This money was used to supplement the operational capital since at the beginning of the operation this model had great need for financing. After these beginning 2 years, this model does not require any borrowing capital since the farm can afford sufficient operating capital with the money generated by selling its production.

In this model there was no need to use the lending activity at any level. This means that the lending activity is not profitable compared with other crops and sugarcane activities at the level of a 6% interest rate. Perhaps if the rate of interest were increased, this activity might have been entered into the solution. However, in this model, this kind of variation of the rate of interest was not analyzed. It is expected in future analyses.

The capital transfer activity is entered in the solution at the level of Cr $30,266.89 and Cr $5,250.64 in the 4th and 5th years respectively. This occurred because the first year had a deficit and the net income turned out to be positive. In the 3rd year the influence of the first 2 years continued, so there is no transfer capital to the next year. In the 6th year there is no capital transfer again and further, the net income turned out to be negative again. From the 7th year to 11th years there is always capital transfer from the maximum quantity of Cr $58, 384.32 at the 9th year, to the minimum quantity of Cr $18,465.96 at the 11th year. An interesting point is that there is no inventory accumulation, i.e., there is no capital transfer from the 12th year to the inventory, even though there is Cr $12,996.10 net income in the 12th year.

In the net income column 2 years have negative net incomes at the levels of Cr $20,520.21 and Cr $14,521.21 in the first and 6th years respectively. This occurs because in the first year there is no profitable production such as the sugarcane that requires production period over time. Even though there exists a second profitable activity, cotton, the net income of this activity does not cover the deficit of the former return. The second negative net income happens to be in the 6th year, because the 5th year does not plant enough area to cover the deficit in the next year, considering the total profit planning. As we can see in the cash flow column, the 5th year requires a great quantity of cash, continued until the 6th year at the level of Cr $34,101.28. Naturally, in this situation, the 6th year cannot transfer any capital to the 7th year.

All cash flow figures are described in the negative sign in order to identify the outflowing quantity of cash for each year. This cash flow ranges from the maximum amount of Cr $47,538.67 to the minimum amount of Cr $21,249.62 in the 10th and 9th years respectively.

Table 51. Financial activities and net income and cash flow for each year--tractor type I model

Year	Unit	Capital borrowing	Capital lending	Capital transfer	Net income	Cash flow
1	Cr$	18,689.77			-20,520.21	-39,819.74
2	Cr$	16,277.99			13,917.85	-45,995.59
3	Cr$				8,146.85	-24,209.20
4	Cr$			30,266.89	20,996.32	-23,891.28
5	Cr$			5,250.64	3,362.39	-45,135.08
6	Cr$				-14,521.21	-34,101.28
7	Cr$			28,687.60	19,417.03	-37,116.38
8	Cr$			45,581.41	17,511.76	-31,960.27
9	Cr$			58,384.32	6,615.77	-21,249.62
10	Cr$			38,483.27	11,562.66	-47,538.67
11	Cr$			18,465.96	11,444.74	-43,981.52
12	Cr$				12,996.10	-38,756.75

This variation comes from the variation of the quantity of activity from year to year beyond the fixed cost and living cost that are the fixed quantities.

All these activities are shown in Table 51 in summary form.

Shadow prices

Shadow price is defined as a value to be imputed to the resources (3, 14). Shadow prices indicate limited resources. In this model these limited resources are land, labor and capital. The figures of shadow prices are shown in the value of Cr $ summarized in Table 52.

The shadow price of land is the lowest at the level of Cr $256.32 and the highest at the level of Cr $1,000.41 in the first and 2nd years, respectively, because in the first year there is not enough planting area for the sugarcane production that is more profitable in the model, considering the overtime profit. The percentage of the total area in cane in the first and 3rd years is 64 and 100 respectively. This means that even though all lands are exhausted for production purposes there are variations in land value through the final output profitability. Therefore, when all land areas are occupied by the more profitable activities of production--various sugarcane activities in this model, such as in the 3rd year--the shadow price of land is tremendously increased. This is fundamental of the land valuation of the linear programming framework.

In this region the rent per alqueire is around Cr $300.00 on the average in 1969. Therefore, in this model land can be introduced more into the sugarcane production after the 3rd year.

Unfortunately, the optimization of shadow prices has not been done in this research. It is expected this kind of research will be done in the future.

Simple labor activity is divided into two periods, the planting and weed treatment period, November to April, and the harvesting period, May to October. Therefore, shadow prices are divided into two periods. The shadow price of the period of November to April ranges from a maximum of Cr $6.01 in the first year to Cr $4.93 which continues after the 7th year to the 12th year. The shadow price of labor of the May to October period ranges from Cr $5.62 in the 2nd year, which is the highest to Cr $4.93 from the 7th year to the 12th year, which is the lowest. These shadow prices are higher than the market price of Cr $4.80 in this model. Therefore, hiring more labor for the production activities is to be expected. However, the present research does not do this kind of analyses.

The shadow price of capital means that if one unit of capital is introduced into the model the net income is increased at the level of Cr $.25. This is to show that the return of capital is Cr $.25 or 25% in this dynamic linear programming framework. This return in the first year is above the cost of capital, 7%. This high return of capital continues until the 3rd year when the rate of return is 9%. After the 3rd year in the 4th to 6th years, the rate of return is Cr $.05, which is below the cost of capital. Further, in the 7th to 12th years, the rate of return is decreased to Cr $.03.

Table 52. Shadow prices for the resources--tractor type I Model

Year	Land per alqueire	Labor, November-April per day	Labor, May-October per day	Tractor I per day	Mule per day	Capital per Cr$
1	Cr$ 256.32	Cr$ 6.01				Cr$ .25
2	Cr$ 260.15	Cr$ 5.62	Cr$ 5.62			Cr$ .17
3	Cr$ 1,000.41	Cr$ 5.25	Cr$ 5.25			Cr$ .09
4	Cr$ 582.26	Cr$ 4.62	Cr$ 5.03			Cr$ .05
5	Cr$ 492.59	Cr$ 5.03	Cr$ 5.03			Cr$ .05
6	Cr$ 509.44	Cr$ 5.03	Cr$ 5.03			Cr$ .05
7	Cr$ 587.33	Cr$ 4.93	Cr$ 4.93			Cr$ .03
8	Cr$ 530.83	Cr$ 4.93	Cr$ 4.93			Cr$ .03
9	Cr$ 530.83	Cr$ 4.93	Cr$ 4.93			Cr$ .03
10	Cr$ 530.83	Cr$ 4.93	Cr$ 4.93			Cr$ .03
11	Cr$ 530.83	Cr$ 4.93	Cr$ 4.93			Cr$ .03
12	Cr$ 530.83	Cr$ 4.93	Cr$ 4.93			Cr$ .03

Summary and analyses

This model begins with Cr $11,859.40 of the operational variable costs. Further, in the first 2 years this model borrowed capital outside at the rate of 7% interest since the rate of return of capital of the first 3 years is above the cost. From the characteristics of the model, the first year does not have any production of sugarcane, the most profitable in this model since the sugarcane takes at least 18 months for the first harvesting. This means that in the first year there is only investment in the sugarcane production. This phenomenon of the characteristics of the sugarcane production cycle is reflected in the net income, which is negative at the level of Cr $20,520.21. As time advances, the area of the sugarcane production varies, arriving at the highest level of 23.34 alqueires in the 3rd year, in the 6th year and in the 7th year. The net income in the 6th year is negative at the level of Cr $14,521.21 again. This happened because the cane-harvest-harvest-harvest cycle activity that would have began in the second year begins to be planted in the 6th year at the level of 15.29 alqueires, which is more than half of the area of the total farm land of this model. The cost of planting this area increased tremendously over the net income of the first cane-harvest-harvest-harvest (D) at the level of 4.02, as in Table 48. However, this sacrifice of the 6th year is returned the next year at the second highest level of the net income at Cr $19,417.03.

In the crop activities, only the activity is entered into the solution in the beginning years of this model at the level of 8.37

alqueires and at the end of these years at the highest level 16.54 alqueires. This means that only cotton activity is profitable in crop activities and is competing with the sugarcane activities in the model.

From the model construction the cotton activity supplements the sugarcane activities, seen in Tables 48 and 49. In the beginning years and in the final years the cotton activity occupies more land substituting for the sugarcane activities. This occurs because the sugarcane activities work only by cycle over various periods. Once the specific activity occupies a specific area, it usually continues to occupy that area until the end of that activity. This happens only if this cycle of sugarcane is profitable. If the ending year of the sugarcane activity cycle is not profitable, the area occupied by this activity might be reduced and replaced by the other activities.

The shadow prices of land are somewhat above the market price level except for the first 2 years, which are below the market price of Cr $300.00.

The return of the labor is always above the market price, which is Cr $4.80 in this model. This means that the more labor is hired the more net income is increased. The present study did not analyze how much the labor should be increased to be optimized.

If we use the constant working labor hired on the farm at the level of 25 working days per month, the level of working days over 6 months is 150. The planting and weed treatment period from November to April is considered to be equivalent to the 150 working labor days, i.e., 6 months. Further, the other period of harvesting covers 6 months, equivalent to the 150 working labor days defined in the model.

To obtain the number of persons who get jobs constantly on the farm, the number of days is divided by the 150 working labor days for each period, and the total labor days in Table 50 is divided by the 300 working labor days. The latter result is not helpful if the number of constant working persons is calculated over the entire year because the quantity of the labor requirement changes from one period to another. In the planting and weed treatment period, more labor is required in some years than in the harvesting period. In other years, the above situation is reversed completely. However, this total number of persons is expressed over the year by dividing the 300 working days. The resulting figure shows the number of persons who need the constant employment opportunity over the entire year on the farm.

The number of workers required in this model changes from year to year. In the planting and weed treatment period the maximum number of laborers required is 9 in the first year and the minimum number of workers is zero in the 4th year, because only 4.02 alqueires of the sugarcane absorbing many laborers is newly planted. This operation does not need extra hired labor to complete the sugarcane and farm operation, which includes 8.37 alqueires of cotton land. This means that in the 4th year there is enough labor to execute the operation of the farm from within the farms.

Tractor type II Model

This section and the following sections of the presentation of the results and analyses of the models are on the same order as those of the tractor type I. Further, the objective function is not discounted as has already been explained in the tractor type I Model section.

This model uses the tractor type II, defined as the tractor having 45 to 69 horsepower. This classification is made primarily depending on the soil preparation method.

In this model the objective function value is Cr $264,797.63 over 12 years. This figure is fairly high considering the size of the farm, which belongs to class V in the present study classification. The fundamental source of net income of this objective function comes from the lending activity. This means that the lending activity is so profitable that the other activities are not permitted in the solution in order to maximize the net income. Further, as in other activities, this lending activity assumes no limitation for the borrowing customer. If some restriction is placed on the lending activity, (usually from financially imperfect market conditions that are very common in the underdeveloped countries), the figure of the objective function is completely different. The extreme operation on this point is done by calculating without the lending activity. The result is a very interesting one, for the objective function value is reduced tremendously to Cr $98,833.01, one-third of the above objective function value. This second calculation is not presented in this section in order to maintain the uniformity of the presentation.

Sugarcane activities

The unit of activity of the tractor type II model is the alqueire. The following models used alqueire in the sugarcane and crop activities.

In the first year the cane-harvest-harvest-harvest activity is entered into the solution at the level of 36.36 alqueires. This activity continues at the same level until the 3rd year. However, an interesting thing happened in the 4th year. This activity level is reduced to 25.10 alqueires, because one part of this activity area, 1.26 alqueires, stopped producing ratoon cane. This area is replaced for the new planting activity of the cane-harvest-harvest-harvest (D) which begins to enter into the solution in the 4th year at the level of 11.27 alqueires. After the 5th year to the 11th year this cane-harvest-harvest-harvest activity continues to occupy the same area at the level of 25.10 alqueires. However, again, in the final year, this sugarcane activity is reduced to 21.45 alqueires in order to transfer 3.65 alqueires into the cotton cultivation that is more profitable than this second ratoon cane activity.

In the second year the cane-harvest-harvest-harvest (B) activity is entered into the solution, at the level of 10.66 alqueires. This activity maintains the same level of activity until the 9th year, having two cycles in total.

In the 4th year the new activity of cane-harvest-harvest-harvest (D) is introduced at the level of 11.27 alqueires. This 4-year,

Table 53. Area of sugarcane--tractor type II Model[a]

Year	Unit	Cane-harvest	Cane-harvest-harvest	Cane-harvest-harvest-harvest	Cane-harvest (B)	Cane-harvest-harvest-harvest (B)	Cane-harvest-harvest (C)	Cane-harvest-harvest-harvest (C)	Cane-harvest-harvest-harvest (D)	Total of cane area	% of total area in cane	Output of sugarcane: Unit	Output of sugarcane: Total output
1	Alqueire			36.36						36.36	77		
2	Alqueire			36.36		10.66				47.03	100	ton	5,090
3	Alqueire			36.36		10.66				47.03	100	ton	4,766
4	Alqueire			25.10		10.66			11.27	47.03	100	ton	2,967
5	Alqueire			25.10		10.66			11.27	47.03	100	ton	2,430
6	Alqueire			25.10		10.66			11.27	47.03	100	ton	4,528
7	Alqueire			25.10		10.66			11.27	47.03	100	ton	4,653
8	Alqueire			25.10		10.66			11.27	47.03	100	ton	2,968
9	Alqueire			25.10		10.66			11.27	47.03	100	ton	2,431
10	Alqueire		10.66	25.10					11.27	47.03	100	ton	4,528
11	Alqueire		10.66	25.10					11.27	47.03	100	ton	4,653
12	Alqueire		10.66	21.45						32.11	68	ton	2,676
Total													41,690

[a](B), (C) and (D) first planted in the 2nd, 3rd and 4th years, respectively.

one-cycle activity continues until the 11th year at the same level of land occupation.

In the 10th year the cane-harvest-harvest activity is newly introduced at the level of 10.66 alqueires, continuing to occupy the same quantity of the area until the 12th year. All these are the sugarcane activities that are entered into the solution in this model. The total sugarcane planted area is shown by a percentage as well as in alqueires. As can be seen in Table 57 of shadow prices, only in the 1st year is the total arable land not utilized: only 77% is cultivated in the production activity. From the 2nd year on until the final 12th year, all arable lands are used completely, either by sugarcane activities or by crop activities. From the 2nd year to the 11th year 100% of the arable lands are occupied by the sugarcane activities. In the 12th year the sugarcane area is reduced to 68% because of the technical and cyclical characteristics of the sugarcane activity.

The total production of the sugarcane of this model varies from the maximum output of 5,090 tons at the second year to the minimum output of 2,430 tons at the 5th year. This physical production of the sugarcane is considered with the net income.

The above description is summarized in Table 53.

Crop activities

In this model only one crop activity, the cotton activity, is entered into the solution at the level of 14.91 alqueires in the last year, because the sugarcane activities are more profitable than the

Table 54. Area of crop land--tractor type II Model

Year	Unit	Cotton	Corn-animal	Corn-tractor	Rice	Total crop land	% of total areas in crop
1	Alqueire						
2	Alqueire						
3	Alqueire						
4	Alqueire						
5	Alqueire						
6	Alqueire						
7	Alqueire						
8	Alqueire						
9	Alqueire						
10	Alqueire						
11	Alqueire						
12	Alqueire	14.91				14.91	32

crop activities until the 12th year. Even though the first year has the slack activity of the land 10.66 alqueires, any other crop activity is not entered into the solution, the planting and weed treatment of the sugarcane activities at the level of 36.36 alqueires require too many tractor days, laborers from November to April, and capital. There is no way to introduce crop activities into the solution even if the arable land area is in oversupply. This problem is presented by the shadow prices in Table 57. The tractor usage, the labor of November to April and capital returns are too high to permit the entrance of any crop activity into the solutions. Unfortunately, the present study does not analyze the change of the resource restriction considering the shadow prices. It is expected in future research, however.

The crop activities are shown in summary form in Table 54.

Hired labor activities

In the first year only one labor activity from November to April is entered into the solution, since most labor usable activities which enter the solution are the sugarcane activities. The sugarcane activity is an agronomic phenomenon that characterizes the production of the sugarcane over time; i.e., the first year has only the planting and weed treatment activities. This characteristic determines the labor requirement in the first year. The level of quantity of the labor is the highest in the first year at 965 days. If this number is divided by 150 days as in the previous section, we get the number of persons who are employed constantly during this period from

November to April. This is shown in Table 55 in the column of the number of persons hired.

In the 4th, 8th and 11th years hired laborers are not necessary for the planting and weed treatment period, because these years have enough labor available on the farm. An interesting point is that the maximum labor available is exactly used up to that limitation in these years. Therefore, the shadow prices come out as a positive number. The shadow prices are shown in Table 57.

The hired labor of May to October always has positive hired-labor days until the 12th year, except for the first year with zero hired-labor days. This occurs because in the first year the sugarcane activities are only entered into the solution in the planting and weed treatment period. Therefore, there are no first-year activities for the sugarcane harvest which requires the harvesting labor from May to October.

The highest need for hired labor is in the 2nd year at the level of 1,627 days. This quantity of working days translates into almost 11 persons who are continuously employed during this period. From the 2nd year to the 12th year the minimum hired labor requirement goes down to 30 days.

As we have seen in the above descriptions a serious problem exists in the distribution of the hired labor within the year and over the planning years. This should be looked into seriously in future research.

Table 55. Hired labor activities--tractor type II Model

Year	Labor, November to April		Labor, May to October		Total hired labor/year	
	Day	Number of persons hired	Day	Number of persons hired	Day	Number of persons hired
1	965	6.4			965	3.2
2	638	4.3	1,627	10.8	2,265	7.6
3	95	.6	1,432	9.5	1,527	5.1
4			353	2.3	353	1.2
5	700	4.7	30	.2	730	2.4
6	638	4.2	1,289	8.6	1,927	6.4
7	95	.6	1,364	9.1	1,459	4.9
8			353	2.3	353	1.2
9	700	4.7	30	.2	730	2.4
10	638	4.2	1,289	8.6	1,927	6.4
11			1,364	9.1	1,364	4.5
12	60	.4	550	3.7	610	2.0
Total	4,529		9,681		14,210	

Financial activities and net income and cash flow for each year

In this model the most interesting finding is in the capital lending activity that is quite profitable in comparison with other activities. This can be seen in Table 56. The quantity of the capital lending will increase from the minimum level of Cr $8,547.47 in the first year to the maximum level of Cr $553,496.33 in the 12th year. The capital lending quantity is increased each year and this activity is substituted for the capital transfer activity. The role of this activity is explained by the difference of the objective function. If this lending activity is included, the objective function rises to Cr $264,797.63. However, if this activity is not included, the objective function is reduced to Cr $98,833.01. The difference is Cr $165,946.62, which is contributed by the capital lending function. This shows the great profitability of the lending activity. Further, this profitability of the lending activity, assuming that there is no restriction on the lending market, explains why the arable land is not used up in the first year since the available capital is passed to the more profitable lending fund instead of the production activity, as we have seen in the sugarcane activities.

The net income appears negative at the level of Cr $59,805.47 in first year. However, in the following years the net income turns out to be positive. The highest net income is earned in the last year, i.e., the 12th year.

The cash flow increases steadily from the first year to the 12th year because the capital lending activity, which is included in the cash flow category, also increases steadily.

Table 56. Financial activities and net income and cash flow--tractor type II Model

Year	Unit	Capital borrowing	Capital lending	Capital transfer	Net income	Cash flow
1	Cr$		8,547.47		-59,805.47	-68,865.79
2	Cr$		56,102.86		23,532.63	-127,623.68
3	Cr$		113,029.92		33,466.60	-172,181.11
4	Cr$		151,432.59		13,830.73	-200,137.38
5	Cr$		170,550.51		6,611.09	-231,169.21
6	Cr$		220,046.80		25,589.98	-289,201.73
7	Cr$		285,254.65		42,244.22	-343,932.65
8	Cr$		333,990.79		24,784.22	-48,704.79
9	Cr$		364,062.20		4,999.61	-424,650.90
10	Cr$		425,169.20		37,897.33	-494,324.13
11	Cr$		504,742.89		57,472.02	-561,362.39
12	Cr$		553,496.33		61,529.80	-610.096.41

Shadow prices

The land resources are completely used up in this model, except for the first year. Since the lending activity is very profitable, this is the constraint to using the arable land completely as explained above. From the 2nd year on, the land resource shows fairly high shadow prices, compared with the land rental per market price alqueire in this region. The highest shadow price of the land is in the 3rd year, at the level of Cr $1,166.35. The lowest shadow price is in the 12th year at the level of Cr $567.04. This shows that the land resource is very scarce from the 2nd year to the 12th year.

The shadow price of the hired labor of November to April always shows the scarce resource over 12 years, as we can see in Table 57. The highest shadow price of the hired labor of November to April is Cr $7.11 in the first year, as the 36.36 alqueires of the sugarcane planting operation require a very high level of hired labor over the constrained quantity of the labor. The minimum shadow price of the hired labor of November to April is Cr $3.03 in the 11th year, which is below the Cr $3.50 market price of hired labor in this model. However, without this 11th year's shadow price, all other shadow prices of the hired labor of November to April are above Cr $3.50. This means that a good chance for increasing the net income exists if the labor constraints are increased. This kind of analysis is expected in the future.

In the column of the hired labor of May to October the shadow price of the first year is zero. This happens because no activity uses the hired labor of May to October. In this model, since only

Table 57. Shadow prices for the resources--tractor type II Model

Year	Land per alqueire	Labor, November-April per day	Labor, May-October per day	Tractor II per day	Mule per day	Capital per Cr$
1	Cr$	Cr$ 7.11		Cr$ 184.70		Cr$ 1.03
2	Cr$ 658.65	Cr$ 6.71	Cr$ 6.71			Cr$ .92
3	Cr$ 1,166.35	Cr$ 6.33	Cr$ 6.33			Cr$ .81
4	Cr$ 864.68	Cr$ 5.84	Cr$ 5.97			Cr$ .71
5	Cr$ 809.54	Cr$ 5.63	Cr$ 5.63			Cr$ .61
6	Cr$ 717.57	Cr$ 5.32	Cr$ 5.32			Cr$ .51
7	Cr$ 726.00	Cr$ 5.01	Cr$ 5.01			Cr$ .43
8	Cr$ 682.01	Cr$ 4.73	Cr$ 4.73			Cr$ .35
9	Cr$ 643.40	Cr$ 4.46	Cr$ 4.46			Cr$ .28
10	Cr$ 563.92	Cr$ 4.21	Cr$ 4.21			Cr$ .20
11	Cr$ 575.06	Cr$ 3.03	Cr$ 3.97			Cr$ .13
12	Cr$ 567.04	Cr$ 3.75	Cr$ 3.75			Cr$ .07

planting and weed treatment are entered into the solution, there is no necessity for hired labor in this period. In the second year the shadow price of the hired labor of May to October is the highest, at the level of Cr $6.71. The lowest level of the shadow price of this period is in the 12th year, at the level of Cr $3.75.

The tractor type II Model shows the constraint at the level of Cr $184.70, which appears as the shadow price of this constraint in the first year. But the tractor type II has more constraint after the 2nd year, as shown in Table 57.

The highest shadow price of capital is Cr $1.03 for each Cr $1.00, which appears in the first year. AFter the 2nd year up to the 12th year, the shadow price of capital decreases from Cr $.92 to Cr $.07 because in the initial stage of the model there exists a great necessity for capital. However, when the production activities and the financial production activities begin to succeed, net income increases and the necessity for capital decreases more each time. Therefore, the shadow price of capital is gradually reduced until the 12th year.

Summary and analyses

Model II is characterized by the profitable lending activity that contributes to the net income in the quantity of Cr $165,906.62. The assumption of this model admits infinite lending activity, considering the situation of the farm firm in perfect competition. If the aggregation concept is introduced into the model, the capital market constraint should be considered. This kind of consideration will be analyzed in future study.

With the exception of the first year all available lands are used by the production of sugarcane at the level of 100% (Table 53) excluding the final year which occupies 68% of the total arable land. The most profitable production activity is the type of the cane-harvest-harvest-harvest that is entered into the solution in all periods. Further, this type of production activity which begins in the 2nd year and in the 4th year repeats two cycles in each activity. The final activity of the cane-harvest-harvest is entered into the solution in the 10th year for the substitution of 10.66 alqueires of the cane-harvest-harvest-harvest (B). The crop activity comes into the solution only in the final 12th year at the level of 14.91 alqueires of cotton activity in order to use up the available arable land with some profitable production activity.

The hired labor activities vary from year to year and from period to period as can be seen in Table 55. This variation will disturb the absorption of the labor that usually requires constant employment opportunity on the farm. In the labor column of November to April the number of persons hired varies from zero to 7. Further, in the labor column of May to October, the number of persons hired varies from 1 to 11, considering the slack quantity of the labor force and excluding the first year, zero in this model. In future study this variation of labor into the model might be considered to maintain some quantity of constant labor employment over the years using an increased flexibility technique or bound technique in the dynamic or simple linear programming framework.

Tractor type III Model

The capacity of tractor of this model uses above 70 horsepower for the farm operation. This category has the greatest horsepower of three categories of tractors. This big-tractor category is usually correlated with other greater resources.

The objective function of this model is Cr $3,731,705.16 which is an optimal solution of this model. The main source of the objective function, i.e., the net income, comes from the sugarcane production, as will be shown in the following sections. Sugarcane occupies almost all available arable land over 12 years as in Table 59.

This quantity of net income over all 12 years is more than ten times greater than the initial available capital of Cr $331,113.58 in this model. This means that this model accumulated capital steadily over 12 years, even though an irregular path of net income over 12 years is noted upon examination of each year (see Table 61).

Sugarcane activities

The results of the sugarcane activities are shown in Table 58 in summary form. The sugarcane production activity, cane-harvest-harvest-harvest cycle activity is entered into the solution through all the

the 12-year production periods. In the first cycle of this production activity, it is entered at the level of 405.41 alqueires from the first year to the 3rd year. However, in the 4th year the sugarcane production area of this activity is reduced to 298.90 alqueires in order to replace the area of 106.51 alqueires for the sugarcane production activity of cane-harvest-harvest-harvest (D) that begins to plant the sugarcane from the 4th year. This same production activity reduces its area of production further in the 5th year to the level of 235.34 alqueires in the next cycle of the production. In the 9th year, the final cycle of this production activity of sugarcane, the planting area is increased to the level of 251.85 alqueires, which continues until the 12th year.

The 2nd-year planting sugarcane-production activity is the cane-harvest-harvest-harvest (B). This activity is entered into the solution at the level of 51.44 alqueires, mantaining the same level of activity until the 5th year. In the next cycle this activity is increased to the level of 115.00 which is more than double when compared with the previous level of the activity. The second cycle of this activity ends in the 9th year.

In the 4th year the new production activity of sugarcane that is cane-harvest-harvest-harvest (D) is entered into the solution at the level of 106.51 alqueires. This level of activity continues during the first cycle. However, in the second cycle this activity is reduced to 90.00 alqueires. The quantity of this difference, 16.51 alqueires, is prepared to be used in the production activity of the cane-harvest-harvest-harvest which begins in the 9th year. In order to use this area between the 8th year and the 9th year this arable land area, 16.51 alqueires, is used for the production of cotton in the 8th year, as shown in Table 59. The second cycle of this activity of production maintains the same level of quantity until the 11th year.

The 4th new activity that is entered into the solution is the cane-harvest-harvest activity. This activity is entered into the solution at the level of 115.00 alqueires in the 10th year. The level of activity is continued until the 12th year at the same level of 115.00 alqueires.

The usage of the total area in sugarcane is very high. In the column of % of total area in cane in Table 58, the minimum percentage of the total area in cane is 80% in the 12th year. Further, excluding the first, 5th and 8th years that are 80%, 86% and 96% respectively, use in all other years of the total area is 100%. This shows that the production activity of sugarcane is very profitable in this model.

This model belongs to size VIII, a farm which produces more than 10,000 tons of sugarcane. The output of the sugarcane of model ranges from a minimum quantity of 22,186 tons in the 5th year to a maximum quantity of 64,865 in the 2nd year.

Table 58. Area of sugarcane--tractor type III Model[a]

Year	Unit	Cane-harvest	Cane-harvest-harvest	Cane-harvest-harvest-harvest	Cane-harvest-harvest (B)	Cane-harvest-harvest-harvest (B)	Cane-harvest-harvest (C)	Cane-harvest-harvest-harvest (C)	Cane-harvest-harvest-harvest (D)	Total of cane area	% of total area in cane	Output of sugarcane: Unit	Output of sugarcane: Total output
1	Alqueire			405.41						405.41	89		
2	Alqueire			405.41		51.44				456.85	100	ton	64,865
3	Alqueire			405.41		51.44				456.85	100	ton	60,934
4	Alqueire			298.90		51.44			106.51	456.85	100	ton	36,578
5	Alqueire			235.34		51.44			106.51	392.29	86	ton	22,186
6	Alqueire			235.34		115.00			106.51	456.85	100	ton	51,501
7	Alqueire			235.34		115.00			106.51	456.85	100	ton	59,645
8	Alqueire			235.34		115.00			90.00	440.34	96	ton	38,484
9	Alqueire			251.85		115.00			90.00	456.85	100	ton	25,900
10	Alqueire		115.00	251.85					90.00	456.85	100	ton	51,996
11	Alqueire		115.00	251.85					90.00	456.85	100	ton	60,141
12	Alqueire		115.00	251.85						366.85	80	ton	40,135
Total													512,365

[a](B), (C) and (D) first planted in the 2nd, 3rd and 4th years, respectively.

Crop activities

In this model, two crop enterprise, rice and cotton, are entered into the solution. The rice enterprise enters into the solution in the first year at the level of 22.50 alqueires, which corresponds to 11% of the total arable land. In the 5th, 8th and 12th years the cotton enterprise is entered into the solution at the level of 63.56 alqueires, 16.51 alqueires and 90.00 alqueires which corresponds to 14%, 4% and 20% of the total arable land respectively.

These production levels are shown in Table 59. In this model the crop production activities are used only to complement the technical deficiencies of the sugarcane production activity.

Hired labor activities

The size of farm of this model is much greater than the two previous models discussed. This means that this farm keeps many fixed laborers available throughout the year in sufficient quantity for the planting and weed treatement periods. This is shown in the column of labor for November to April where, except for the first year, all 12 years appear at the quantity of zero. In the first year, 1,444 hired labor days are needed, an equivalent of around 10 persons during the planting and weed treatment period, but the harvesting labor level is zero.

Table 59. Area of crop land--tractor type III Model

Year	Unit	Cotton	Corn-animal	Corn-tractor	Rice	Total crop land	% of total areas in crop
1	Alqueire				22.50	22.50	5
2	Alqueire						
3	Alqueire						
4	Alqueire						
5	Alqueire	63.56				63.56	14
6	Alqueire						
7	Alqueire						
8	Alqueire	16.51				16.51	4
9	Alqueire						
10	Alqueire						
11	Alqueire						
12	Alqueire	90.00				90.00	20

Table 60. Hired labor activities--tractor type III Model

Year	Labor, November to April		Labor, May to October		Total hired labor/year	
	Day	Number of persons hired	Day	Number of persons hired	Day	Number of persons hired
1	1,444	9.6			1,444	4.8
2			16,913	112.8	16,913	56.4
3			15,086	100.6	15,086	50.3
4			4,551	30.3	4,551	15.2
5						
6			11,092	73.9	11,092	37.0
7			14,546	97.0	14,546	48.5
8			5,790	38.6	5,790	19.3
9						
10			11,311	75.4	11,311	37.7
11			14,761	98.4	14,761	49.2
12			8,338	55.6	8,338	27.8
Total	1,444		102,388		103,832	

From the 2nd year on harvesting hired laborers are necessary except in the 5th and 9th years. The highest level of the hired harvesting labor is 16,913 days, which is equivalent to 113 workers who are employed constantly during the harvesting period.

Again the variation of the level of the hired labor is great. How to keep employment at constant levels should be considered in future studies.

Financial activities and net income and cash flow for each year

In the first year this model borrows capital of Cr $77,830.40 for production activities. After the first year the model generates sufficient capital for the production activities.

The quantity of the capital transfer to the following year is increased steadily from the minimum quantity of Cr $670,812.87 of the 2nd year to the maximum quantity of Cr $5,498,050.36 of the 12th year. Naturally, in the first year there is no capital transfer to the following year because this year necessitates capital which is borrowed outside of the model beyond the initial available capital.

The net income for each year is negative three times: first year, 5th year and 9th year at the level of Cr $407,518.20, Cr $20,080.36 and Cr $33,271.81 respectively. These negative figure years correspond to the low production years of the sugarcane: zero, 22,186 tons and 25,900 tons in the first, 5th and 9th years, respectively. This means that the basic source of the net income of this model is

Table 61. Financial activities and net income and cash flow--tractor type III Model

Year	Unit	Captial borrowing	Capital lending	Capital transfer	Net income	Cash flow
1	Cr$	77,830.40			-407,518.20	-435,820.07
2	Cr$			670,817.87	579,926.68	-588,289.54
3	Cr$			1,440,700.88	595,713.29	-501,705.13
4	Cr$			1,882,183.45	267,312.85	-391,488.79
5	Cr$			1,879,767.62	-20,080.36	-576,150.42
6	Cr$			2,412,219.63	358,282.29	-569,246.45
7	Cr$			3,164,072.84	577,683.49	-496,527.70
8	Cr$			3,597,906.03	300,314.16	-433,437.16
9	Cr$			3,738,803.94	-33,271.81	-499,730.81
10	Cr$			4,278,067.44	365,093.78	-571,354.18
11	Cr$			5,030,699.49	578,462.33	-504,668.07
12	Cr$			5,498,050.36	514,806.15	-429,650.20

from the sugarcane production activities (again). The highest net income is earned in the 2nd year, Cr $595,713.29.

The cash flow figures show fairly constant from the maximum level of Cr $588,289.54 in the 2nd year to the minimum level of Cr $391,488.79 in the 4th year. This cash flow shows the necessary quantity of cash for each year for 12 years in order to obtain the level of the net income for each year as shown in the net income column in Table 61 for this size of farm.

Shadow prices

The shadow price of land in this model shows a fairly high figure compared with the market rent price of land. However, the first year is zero, since the tractor available days, capital, and mule available days acted as constraints to limit the use of more land for the production activity. Nevertheless, after the 2nd year the shadow price of land shows a very high figure from the maximum figure of Cr $1,030.08 to the minimum figure of Cr $671.81. In this region the rate of rent of land averages Cr $300.00. If we consider this price as the market price, the highest year of the shadow price is almost 3.5 times greater than the market price. Even though the figure of Cr $671.81 is the lowest of the shadow prices of land in the 12th year, it is more than two times greater than the rent of the market price. This suggests that this model could make more future analyses of expansion through changing limitation.

The shadow price of labor is Cr 3.79 in the labor period of November to April, used to plant the sugarcane and treat weeds in the first year. However, this price is lower than the market price that costs Cr $4.80 in this model. This suggests that the constraint of the labor of November to April should be reduced a little more in order to increase the level of the shadow price to that of the market price. From the 2nd year on, there are only zero levels of shadow prices for this period of labor. This means that there is an oversupply of labor in this model. As before, the present study does not analyze the level of shadow prices; that will be left for future studies.

In the labor column of the period of May to October, the shadow prices of the first year, 5th year and 9th years are zero, Cr $2.30 and Cr $2.22 respectively. These years are definitely correlated with the sugarcane harvesting activities. Since these three years have a low level of sugarcane production compared with other years, the net income is negative as we have seen in the section of the financial activities. Excluding these three years, the level of the shadow prices for labor in this period is kept at the level of Cr $4.85, which is slightly higher than the market price of Cr $4.80.

The tractor III and the mule power are necessary over those constraints in the first year at the level of Cr $211.55 and of Cr $4.07 per day respectively. Further, the shadow price of the mule power per day is increased to Cr $11.36 in the 12th year because of the expansion of the crop activities.

Table 62. Shadow prices for the resources--tractor type III Model

Year	Land per alqueire	Labor, November-April per day	Labor, May-October per day	Tractor IV per day	Mule per day	Capital per Cr$
1		Cr$ 3.78		Cr$ 211.55	Cr$ 4.07	Cr$ .08
2	Cr$ 926.81		Cr$ 4.85			Cr$ .01
3	Cr$ 996.21		Cr$ 4.85			Cr$ .01
4	Cr$ 1,030.08		Cr$ 4.85			Cr$ .01
5	Cr$ 917.27		Cr$ 2.30			Cr$ .01
6	Cr$ 959.92		Cr$ 4.85			Cr$ .01
7	Cr$ 1,030.08		Cr$ 4.85			Cr$ .01
8	Cr$ 853.61		Cr$ 4.85			Cr$ .01
9	Cr$ 1,030.08		Cr$ 2.22			Cr$ .01
10	Cr$ 1,030.08		Cr$ 4.85			Cr$ .01
11	Cr$ 1,028.91		Cr$ 4.85			Cr$ .01
12	Cr$ 671.81		Cr$ 4.85		Cr$ 11.36	Cr$ .01

The shadow price of capital of the model is fairly low except in the first year, at a cost of Cr \$.08 per Cr \$1.00. From the 2nd year on to the 12th year all shadow prices are at the same level of Cr \$.01, a fairly low return compared with the market interest rate. Therefore, the capital should be reduced in this model. Again the problem of how much capital should be reduced to bring the model out to the optimal level will be left for future study.

Summary and analyses

This model belongs to the largest size of farms in this region. Therefore, the quantity of activities in this model is the largest. The fundamental production activities are the sugarcane activities noted in Table 58. Further, the most profitable activities are one-cycle, four-year production activities. The second choice of profitability of this model in the sugarcane production activities is the 3-year cycle activity of the cane-harvest-harvest. Excluding the first year, up through the 11th year the land resource is a more valuable one as we have seen in the shadow prices of Table 62. The land is almost always used up by the sugarcane production activities. Naturally, when some land is available for production, this land is brought into production usage by such crop activities as rice and cotton.

Throughout the 12 years the labor does not have such crucial limitation for the model as has been seen in the shadow price presented in Table 62. The labor for the planting and weed treatment period especially shows an oversupply of labor.

The capital shortage occurs only in the first year. This is shown in the shadow price of the capital as Cr $.08. After the first year the capital is generated from the model itself and transferred to the latter years steadily. See the column of capital transfer in Table 61.

Over the whole model the sugarcane activities have a fundamental role in the contribution to the net income.

<u>Tractor type IV Model</u>

This model is composed of two types of models, tractor type I and tractor type II. Further, this model belongs to the size of class IV.

The objective function value of this model attains the level of Cr $210,742.63 over all 12 years. This figure is fairly high compared with the tractor type I Model which had the objective function value at the level of Cr $91,825.55. It is more than two times greater than the objective function value of the tractor type I. However, this value of the objective function is a little smaller than the objective function of the tractor type II, which had Cr $264,797.63 over all 12 years. This happens because primarily the resource restrictions of this model are smaller than the tractor type II since the tractor type II belongs to class V in the size classification. Further technical production methods influence the production activity choices shown in Table 63.

We see clearly from Tables 48 and 53 the difference in the production activity distribution. In the tractor type II Model almost all land is used for the production of sugarcane. However, in the tractor type I Model a great quantity of land is used for the production of the annual crops. The present tractor type IV Model is closer to the tractor type I. However, the objective function value approaches the value of the tractor type II.

Sugarcane activities

The sugarcane activities are similar in pattern to the tractor type I. However, both tractor types are entered in the solution.

In the first year the cane-harvest-harvest-harvest of the tractor type I is entered into the solution at the level of 22.39 alqueires. This activity is maintained at the same level until the 3rd year. In the 4th year, one part of this activity, i.e., 4.65 alqueires, is transferred to and used up by the cane-harvest-harvest-harvest (D) activity as part of the same activity continuously occupies some arable land at various levels until the 12th year. From the 5th to the 8th year it occupies the arable land at the level of 4.23 alqueires. From the 9th to the 12th year the same activity occupies 20.93 alqueires of the arable land at the increased level.

Further, in the first year the cane-harvest-harvest activity of the tractor type II is entered into the solution at the level of 11.75 alqueires. This level of the activity continues until the 2nd year. In the 3rd year the level of this activity is reduced from

11.75 alqueires to 7.95 alqueires, transferring the difference of 3.80 alquieres into the cane-harvest-harvest (C) activity of the tractor type I.

In the 3rd year the cane-harvest-harvest (C) activity of the tractor type I is entered into the solution at the level of 17.74 alqueires. This activity continues only one year. After the first harvesting activity the area of this land is transferred to cotton land, since the cotton activity is more profitable than the 3rd year production of the cane-harvest-harvest activity of the tractor type I.

In the 4th year there is new activity of the cane-harvest-harvest-harvest (D) of the tractor type I at the level of 12.59 alqueires. This activity remains in the solution for two cycles at the varying level of the activity. From the 4th to 7th years this activity maintains the same level of 12.59 alqueires. But from the 8th to 11th years, the level of activity is reduced drastically to 2.81 alqueires.

In the 6th year of this tractor type I activity, again a 4-year cycle activity of the cane-harvest-harvest-harvest (B) is entered into the solution, at the level of 19.88 alqueires and continues until the 9th year at the same level.

In percentage terms, the total area in the sugarcane production is at a relatively low level. Only three years, the 3rd, 4th and 9th, are occupied by the sugarcane production at more than 90% of the total arable area. The minimum usage of the arable land by the sugarcane production is 35% in the 5th year. However, even though the arable

Table 63. Area of sugarcane--tractor type IV Model[a]

		Tractor type I								
Year	Unit	Cane-harvest	Cane-harvest-harvest	Cane-harvest-harvest-harvest	Cane-harvest (B)	Cane-harvest-harvest (B)	Cane-harvest-harvest-harvest (B)	Cane-harvest-harvest (C)	Cane-harvest-harvest-harvest (C)	Cane-harvest-harvest-harvest (D)
1	Alqueire			22.39						
2	Alqueire			22.39						
3	Alqueire			22.39				17.74		
4	Alqueire			17.74				17.74		12.59
5	Alqueire			4.23						12.59
6	Alqueire			4.23			19.88			12.59
7	Alqueire			4.23			19.88			12.59
8	Alqueire			4.23			19.88			2.81
9	Alqueire			20.93			19.88			2.81
10	Alqueire			20.93						2.81
11	Alqueire			20.93						2.81
12	Alqueire			20.93						

[a](B), (C) and (D) are first planted in the 2nd, 3rd and 4th years, respectively.

Table 63. Continued

Year	Unit	Cane-harvest	Cane-harvest-harvest	Total of cane area	% of total area in cane	Output of sugarcane	
						Unit	Total output
1	Alqueire		11.75	34.14	71	ton	
2	Alqueire		11.75	34.14	71	ton	5,003
3	Alqueire		7.95	48.08	100	ton	3,402
4	Alqueire			48.08	100	ton	4,791
5	Alqueire			16.82	35	ton	1,889
6	Alqueire			36.70	76	ton	2,147
7	Alqueire			36.70	76	ton	4,623
8	Alqueire			26.92	56	ton	2,766
9	Alqueire			43.62	91	ton	2,211
10	Alqueire			23.74	49	ton	3,477
11	Alqueire			23.74	49	ton	2,764
12	Alquerie			20.92	44	ton	1,883
Total							34,956

Tractor type II

land is used at this low level by sugarcane production in this model, it is transferred to other crop production alternatives that compete with the sugarcane production activities.

The total output of the sugarcane varies from the maximum level of 5,003 tons in the 2nd year to the minimum level of 1,883 tons in the 12th year. In the 5th year the total production is almost equivalent to that of the 12th year. These figures correspond to the total area of the sugarcane that is shown in the column of the total of cane area in Table 63.

Crop activities

Only one enterprise of all crop enterprises is entered into the solution at all the various levels of activity. This is the cotton activity. The 3rd and 4th years have zero level of this activity although it is entered into the solution at a relatively high level in the other years. The highest level of the cotton activity is 31.25 alqueires in the 5th year, using 65% of the total arable land area. Further, in the 10th, 11th and 12th years the land area which is occupied by the cotton activity is 51, 51, and 56 in percentage terms. The cotton activity makes a relatively profitable contribution to the net income as seen in Table 64.

Table 64. Area of crop land--tractor type IV Model

Year	Unit	Cotton	Corn-animal	Corn-tractor	Rice	Total crop land	% of total areas in crop
1	Alqueire	13.94				13.94	29
2	Alqueire	13.94				13.94	29
3	Alqueire						
4	Alqueire						
5	Alqueire	31.25				31.25	65
6	Alqueire	11.37				11.37	24
7	Alqueire	11.37				11.37	24
8	Alqueire	21.15				21.15	44
9	Alqueire	4.46				4.46	9
10	Alqueire	24.34				24.34	51
11	Alqueire	24.34				24.34	51
12	Alqueire	27.15				27.15	56

Hired labor activities

As in previous models the hired labor activities in this model are divided into two periods: November to April and May to October.

The first hired labor activity is at zero in the 4th year in this model, because the sugarcane activity of the planting and weed treatment period is reduced to a very low level: 12.59 alqueires. With this level of the sugarcane activity, the fixed labor on the farm is sufficient for the sugarcane planting and weed treatment.

The highest number of days of the hired labor activity is 2,169 which is transferred into approximately 15 workers working constantly over this time period. As can be seen in Table 65, there are many variations in the level of the hired labor days, as well as in the number of the hired persons constant over this period. As suggested before, this problem should be studied in the future since this is a very important matter for the labor problem.

In the second period of the hired labor the level of the hired labor is zero in the first and 9th years. In the first year this occurs because almost all arable land is occupied by the planting and weed treatment activities. There is no necessity for the hired harvesting labor for the sugarcane activities. Even though there is a necessity for the hired harvesting labor for the annual cotton crop activity, it is satisfied by the available labor on the farm. In the 9th year (Tables 63 and 65), the hired harvesting labor requirement is around

Table 65. Hired labor activities--tractor type IV Model

Year	Labor, November to April		Labor, May to October		Total hired labor/year	
	Day	Number of persons hired	Day	Number of persons hired	Day	Number of persons hired
1	2,169	14.5			2,169	7.2
2	749	5.0	2,548	17.0	3,297	11.0
3	395	2.6	422	2.8	817	2.7
4			1,686	11.2	1,686	5.6
5	1,612	10.7	917	6.1	2,529	8.4
6	1,746	11.6	199	1.3	1,945	6.5
7	440	2.9	1,981	13.2	2,421	8.1
8	1,115	7.4	558	3.7	1,673	5.6
9	991	6.6			991	3.3
10	1,207	8.0	1,816	12.1	3,023	10.1
11	1,122	7.5	637	4.2	1,759	5.9
12	663	4.4	301	2.0	964	3.2
Total	12,209		11,065		23,274	

half the total arable land area in sugarcane production. However, almost 90% of this harvesting sugarcane activity level is the cane-harvest-harvest-harvest (B) activity at the level of 19.88 alqueires, which is the final harvesting year. This means that the production level per alqueire is decreased and, simultaneously, that the sugarcane harvesting activity does not need much labor. There is only 2.81 alqueires of the cane-harvest-harvest-harvest (D), the first time harvesting in the 9th year, that requires a high level of harvesting labor per alqueire because the first harvest production per alqueire is the highest. However, the total quantity of the production level of this activity is small, thus requiring a small quantity of the total harvesting labor. In the 9th year there is enough available labor on the farm, and consequently, the model does not require any hired harvesting labor.

The highest number of the hired harvesting days is in the 2nd year at the level of 2,548 days. Again, the many variations of the level of the hired harvesting labor day means that there are variations of the employment levels on the farm. The number of persons who are constantly employed on the farm varies from 17 in the 2nd year to zero, as the number of days. In future study this problem will be considered in the model along with the bounding techniques.

<u>Financial activities and net income and cash flow for each year</u>

In this model the first and the 2nd year are financed from outside the model at the level of Cr $56,544.10 and of Cr $34,184.52. An interesting point to note is that even though in two consecutive years the above amounts were borrowed, there is a net income in the 2nd year. The output of the sugarcane is over the input cost with the highest level at 5,003 tons. Further, 13.94 units of the cotton activity are contributed to the net income.

From the first year to the 3rd year there is no capital transference to the following year. However, from the 5th to the 11th year there are positive figures of capital transference. During these 8 years the highest capital transfer is in the 5th year at the level of Cr $55,528.22 and the lowest capital transfer is in the 6th year at the level of Cr $1,846.12. In this year, the net income is negative at the level of Cr $13,292.38. In the 12th year the capital transferring activity turns out to be zero again.

The net income results in negative figures three times at the level of Cr $52,079.52, Cr $13,292.38 and $1 $8,959.12 in the first, 6th and 9th years, respectively. The highest net income year is in the 7th year at the level of Cr $32,909.25. In the final year the net income is marked at the level of Cr $26,824.44.

The cash flow shows fairly uniform figures from the maximum level of Cr $98,240.55 in the 5th year to the minimum level of Cr $50,609.95 in the 3rd year. These figures are shown in Table 66.

Table 66. Financial activities and net income and cash flow--tractor type IV Model

Year	Unit	Capital borrowing	Capital lending	Capital transfer	Net income	Cash flow
1	Cr$	56,544.10			-52,079.52	-82,461.55
2	Cr$	34,184.52			32,347.41	-89,699.30
3	Cr$				10,659.98	-50,609.95
4	Cr$			55,528.22	29,610.77	-56,666.84
5	Cr$			17,229.22	12,736.68	-98,240.55
6	Cr$			1,846.12	-13,292.38	-79,961.98
7	Cr$			32,664.63	32,909.25	-78,362.44
8	Cr$			26,495.25	20,004.66	-81,908.39
9	Cr$			32,463.79	-8,959.17	-59,769.48
10	Cr$			23,656.97	25,212.85	-97,340.02
11	Cr$			14,123.50	24,483.77	-85.239.38
12	Cr$				26,824.44	-73,960.79

Shadow prices

The shadow price of the land ranges from a minimum of Cr $429.75 in the first year to Cr $871.70 in the 4th year. After the 6th year to the 12th year, the shadow price of land shows the same level of Cr $601.27.

Using the rent price of land per alqueire as Cr $300.00 for this region, any year of the shadow prices in this model is fairly high, ranging from the lower level of almost 1.5 times the rent price to the upper level of almost 3 times the rent price in the 4th year.

The shadow prices of hired labor from November to April always have positive figures. In the 4th year the activity of this period is entered into the solution at an almost positive level. So the shadow price of this resource, the hired labor, is small, Cr $.58. The maximum level of the shadow price is Cr $4.75 in the first year and the minimum level is in the 2nd year as shown in Table 67. From the 5th year to the final year the shadow price is maintained at the same level of Cr $4.11. Except for the 5th year shadow price all prices are above the market price of Cr $4.00.

The shadow price of the hired labor of May to October is zero in the first year, since there is no sugarcane harvesting activity requiring a lot of hired labor. From the 2nd year to the 3rd year the shadow price changes from Cr $4.44 to Cr $4.15; from the 4th year to the 12th year the shadow price of hired labor, April to October, continues at the same level of Cr $4.11. This does not mean that the amount of the labor requirement is the same during these years, although

Table 67. Shadow prices for the resources--tractor type IV Model

Year	Land per alqueire	Labor, November-April per day	Labor, May-October per day	Tractor I per day	Tractor II per day	Mule per day	Capital per Cr$
1	Cr$ 429.75	Cr$ 4.75		Cr$ 26.59			Cr$ .19
2	Cr$ 451.83	Cr$ 4.44	Cr$ 4.44				Cr$ .11
3	Cr$ 620.12	Cr$ 4.15	Cr$ 4.15				Cr$ .04
4	Cr$ 871.70	Cr$ .58	Cr$ 4.11				Cr$ .03
5	Cr$ 592.35	Cr$ 4.11	Cr$ 4.11				Cr$ .03
6	Cr$ 601.27	Cr$ 4.11	Cr$ 4.11	Cr$ 8.75			Cr$ .03
7	Cr$ 601.27	Cr$ 4.11	Cr$ 4.11				Cr$ .03
8	Cr$ 601.27	Cr$ 4.11	Cr$ 4.11				Cr$ .03
9	Cr$ 601.27	Cr$ 4.11	Cr$ 4.11				Cr$ .03
10	Cr$ 601.27	Cr$ 4.11	Cr$ 4.11				Cr$ .03
11	Cr$ 601.27	Cr$ 4.11	Cr$ 4.11				Cr$ .03
12	Cr$ 601.27	Cr$ 4.11	Cr$ 4.11				Cr$ .03

this level of the shadow price continues at the same level of Cr $4.11 within some range of the activity level.

The tractor I column shows the shadow price in the first year and in the 6th year, of Cr $26.59 and Cr $8.75 respectively (Table 67).

The shadow price of the capital shows fairly high level in the first 2 years. These two levels are Cr $.19 in the first year and Cr $.11 in the 2nd year. These shadow prices are higher than the interest rate of the borrowed capital. Therefore, the borrowing activities are entered into the solution in these first 2 years. In the 3rd year the shadow price of capital drops drastically because the model was able to generate capital by the sugarcane production activities and the crop production activity.

From the 4th to the 12th years, the shadow price of capital decreases to Cr $.03 and is maintained at that same level continuously as shown in Table 67.

<u>Summary and analyses</u>

Throughout this model the land is completely used up, either with the sugarcane activities or the crop activities. However, the shadow prices of the land are not as high as have been seen above in Table 67. Further, the usage of the land in the sugarcane is not as high through all the years. In the 3rd, 4th and 9th years, there is very high usage of land in the sugarcane production. Other land is used by the cotton enterprise and in the crop activities only the cotton activity is entered into the solution.

The sugarcane activity is divided into two types of activities. One is the tractor type I and the other is the tractor type II. In the tractor type II only one production activity, the cane-harvest-harvest, is entered into the solution. This means that the tractor type I activities are more profitable than the tractor type II activities. At this level of the model the smaller tractor type activity is more profitable.

Table 65 shows that the variations of the hired labor activities are fairly high over all years. However, from the shadow-price point of view, these variations are within the same range of the shadow prices.

This model has borrowed capital in the first 2 years. But the net income has positive results in the 2nd year with the high production of sugarcane. The net income of all the years is Cr $210,742.63 which approaches the tractor type II Model that belongs to class V of the size classification.

Tractor type V Model

This model comprises two type of tractors, tractor type II and tractor type III. The tractor type II has medium horsepower ranging from 49 to 69, while the tractor type III has the highest horsepower category of more than 70.

The size of this model belongs to the class VIII, the largest class in the present study. The size of this model is shown in arable land area as one of the factor indicators of size, and the total available land of this model is 456.86 alqueires.

The figure of the objective function of this model is Cr $3,275,244.90 over all 12 years. This is the net income of this model, a little lower than the net income of the tractor type III, Cr $3,731,705.16. The difference of the net income between model III and model V is Cr $456,460.26. This difference exists because the sugarcane activities are restricted by the tractor type III constraints in model V. Therefore, even though the sugarcane activities are more profitable than other crop activities, the model has to shift the activities to the cotton enterprise, which does not need much tractor III usage and is relatively profitable. This change of the choice by the restriction of the available tractor type III reduces the value of the objective function by Cr $456,460.26. Even though the tractor type V Model is chosen the tractor type III activities of the sugarcane production are more profitable than the tractor type II activities as detailed in Table 68.

Sugarcane activities

In this tractor type V Model only tractor type III sugarcane activities are entered into the solution. Tractor type II sugarcane activities are not entered into the solution. This shows the relation between size of farm and size of machine. On this size of farm a large machine is more advantageous for sugarcane production. This has already been shown in our previous research of the cost of production of the sugarcane (17).

In the first year two activities are in the solution: the cane-harvest activity and the cane-harvest-harvest-harvest activity.

The cane-harvest activity is entered into the solution at the level of 78.41 alqueires, which is maintained in the first cycle. In the 11th year this activity of the cane-harvest appears in the solution at the level of 20.81 alqueires again. The level of 20.81 alqueires is continued to the 12th year at the same level.

The activity of the cane-harvest-harvest-harvest is entered into the solution at various levels at a decreasing rate. In the first 4-year cycle the level of activity is 135.14 alqueires. In the 2nd 4-year cycle the level of activity is reduced somewhat to 102.41 alqueires. Further, in the final 4-year cycle the level of activity is reduced to 92.30 alqueires.

In the 2nd year the cane-harvest-harvest-harvest (B) is entered into the solution at the level of 112.31 alqueires in the first cycle. In the 2nd 4-year cycle the level of this activity is reduced to 100.88 alqueires. This activity is terminated in the 9th year.

In the 3rd year the cane-harvest-harvest-harvest (C) is entered into the solution at the level of 93.34 alqueires, which continues during the first 4-year cycle, i.e., until the 6th year. In the second 4-year cycle this activity is increased to 100.89 alqueires. This activity is terminated in the 10th year.

In the 4th year, again, the new activty of the cane-harvest-harvest-harvest (D) is entered into the solution at the level of 100.40 alqueires in the first 4-year cycle. In the 2nd 4-year cycle the same activity is increased to 152.77 alqueirès.

These last two activities are contracted with the first three activities which decrease each year. However, the last two activities are increasing their activities year by year. See Table 68.

In addition to the above phenomena, in the 10th year the cane-harvest-harvest activity is entered into the solution at the level of 93.74 alqueires which continues until the 12th year.

The model attempts to obtain to get more balanced distribution of the profitable production of the sugarcane over 12 years. The sugarcane is compared with the crop activities from the point of profitability.

In the beginning years the total area of the sugarcane is less than 50%. However, the sugarcane area is increased gradually to 100% at the 8th year. After the 8th year the total area of the sugarcane decreases gradually to 45% in the final 12th year. This occurs because of the technical characteristics of sugarcane planting and the restriction on the number of available days of tractor type III.

The total output of production is always above 10,000 tons, which is the size classification line constructed in the sampling section. The highest production happens to be in the 9th year at the level of 47,634 tons, even though the highest land area in the sugarcane production is in the 8th year which is before the year of the highest output. Over the years there is sometimes a lag between the planting operation and the harvesting operation.

Table 68. Area of sugarcane--tractor type V Model[a]

Year	Unit	Tractor type III											Output of sugarcane	
		Cane-harvest	Cane-harvest-harvest	Cane-harvest-harvest-harvest	Cane-harvest (B)	Cane-harvest-harvest (B)	Cane-harvest-harvest-harvest (B)	Cane-harvest-harvest (C)	Cane-harvest-harvest-harvest (C)	Cane-harvest-harvest-harvest (D)	Total of cane area	% of total area in cane	Unit	Total output
1	Alqueire	78.41		135.14							213.55	47		
2	Alqueire	78.41		135.14			112.31				325.86	71	ton	34,167
3	Alqueire			135.14			112.31		93.34		340.79	75	ton	35,537
4	Alqueire			135.14			112.31		93.34	100.40	441.19	97	ton	43,048
5	Alqueire			102.41			112.31		93.34	100.40	408.46	89	ton	39,428
6	Alqueire			102.41			100.88		93.34	100.40	397.03	87	ton	38,771
7	Alqueire			102.41			100.88		100.80	100.40	404.49	89	ton	39,493
8	Alqueire			102.41			100.88		100.80	152.77	456.86	100	ton	39,482
9	Alqueire			92.30			100.88		100.80	152.77	446.75	98	ton	47,634
10	Alqueire		93.74	92.30					100.80	152.77	439.61	96	ton	44,708
11	Alqueire	20.81	93.74	92.30						152.77	359.62	79	ton	42,274
12	Alqueire	20.81	93.74	92.30							206.85	45	ton	24,746
Total														429,288

[a](B), (C) and (D) first planted in the 2nd, 3rd and 4th years, respectively.

Crop activities

Crop activities of cotton and corn are entered into the solution as supplementary to the sugarcane. The sugarcane activities are very profitable in this model, but the sugarcane activities consume much more of the tractor type III, which is the restriction of this model. This forces a second alternative of another production which does not need many tractor type III days and is relatively profitable.

The cotton activity is always entered into the solution, except in the 8th year which has zero. The highest cotton activity is 250.00 alqueires in the 12th year. In this same year the cotton area occupies 250.00 alqueires of the total arable land, which is 55%.

The corn activity is entered into the solution only in the first year at the level of 78.40 alqueires.

The total crop land in the first period is more than half the total arable land area of this model.

The arable land area of this model is always utilized either in sugarcane production activities or crop production activities. The degree of the arable land necessity is shown in the shadow price figures.

Hired labor activities

The hired labor, November to April, is entered into the solution only in the first year and in the 12th year at the level of 5,452 days

Table 69. Area of crop land--tractor type V Model

Year	Unit	Cotton	Corn-animal	Corn-tractor	Rice	Total crop land	% of total areas in crop
1	Alqueire	164.90		78.40		243.30	53
2	Alqueire	131.00				131.00	29
3	Alqueire	116.07				116.07	25
4	Alqueire	15.67				15.67	3
5	Alqueire	48.40				48.40	11
6	Alqueire	59.83				59.83	13
7	Alqueire	52.37				52.37	11
8	Alqueire						
9	Alqueire	10.11				10.11	12
10	Alqueire	17.25				17.25	14
11	Alqueire	97.23				97.23	21
12	Alqueire	250.00				250.00	55

Table 70. Hired labor activities--tractor type V Model

Year	Labor, November to April		Labor, May to October		Total hired labor/year	
	Day	Number of persons hired	Day	Number of persons hired	Day	Number of persons hired
1	5,452	36.3			5,452	18.2
2			6,891	45.9	6,891	23.0
3			7,070	47.1	7,070	23.6
4			7,778	51.9	7,778	25.9
5			7,041	46.9	7,041	23.5
6			7,046	47.0	7,046	23.5
7			7,170	47.8	7,170	23.9
8			5,856	39.0	5,856	19.5
9			9,640	64.3	9,640	32.1
10			8,535	56.9	8,535	28.5
11			9,483	63.2	9,483	31.6
12	2,387	15.9	5,728	38.2	8,115	27.1
Total	7,839		82,238		90,077	

and of 2,387 days respectively. The low requirement of hired labor in this period comes from the restriction of days available for tractor type III, since the planting and weed treatment period needs the tractor type III more for the sugarcane operation. Therefore, if the level of the tractor type III available days is limited at a low level hired labor is not needed, as mentioned in the sugarcane activity section.

The hired labor, May to October, is entered into the solution from the 2nd year to the 12th year at a relatively constant level. This can be seen in the section of the shadow prices. Even though there are some variations of the hired labor from 9,640 days in the 9th year to 5,728 days in the 12th year, the shadow price of the hired labor remains constant over these variations of the activity level.

In terms of workers the period of November to April has hired simple labor in the quantity of 37 persons in the first year and 16 persons in the 12th year.

In the harvesting period the quantity of the constantly employed number of persons varies from the maximum of 65 persons in the 9th year to the minimum of 39 persons in the 12th year. Even though these variations are within the constant shadow price, from the view of labor absorption there is a serious problem. This problem will be analyzed by future study.

<u>Financial activities and net income and cash flow for each year</u>

This model borrowed capital at the level of Cr $80,747.66 in the first year. But from the 2nd year on there is no entrance of the borrowing activity in this model because the model could finance the necessary capital by the production activities internally.

The capital transfer increases steadily from the 2nd year at the level of Cr $74,270.60 to the 11th year at the level of Cr $3,488,252.39. In the 12th year the capital transfer is decreased to Cr $3,473,934.52 because the most profitable production activity (sugarcane) has dropped to less than half of the total arable land. This pushes down the income as well as the quantity of the transfer of capital.

In the first year the net income is negative at the level of Cr$249,937.61, since the system is financed from the outside with the expectation of future returns. After the 2nd year all net income figures are positive (Table 71). The highest net income figure is Cr $423,229.44 in the 11th year.

The cash flow varies between the maximum level of Cr $720,919.87 in the first year and the minimum level of Cr $526,772.77 in the 9th year. There is no large variation in the cash flow.

Shadow prices

The shadow price of land in the first year is fairly low at the level of Cr $84.77 per alqueire because in the first year the tractor type III available-day acts as a strong restriction on the model. This reduces the quantity of the most profitable sugarcane activities causing the marginal productivity of the land (in the marginal analysis sense) to push through the profitability of the activity choice. This

Table 71. Financial activities and net income and cash flow--tractor type V Model

Year	Unit	Capital borrowing	Capital lending	Capital transfer	Net income	Cash flow
1	Cr$	80,747.66			-249,937.61	-720,919.87
2	Cr$			74,270.60	272,090.98	-665,839.59
3	Cr$			254,674.12	255,064.07	-670,776.05
4	Cr$			680,849.68	280,700.74	-560,271.01
5	Cr$			1,034,357.81	261,525.86	-567,755.84
6	Cr$			1,358,625.30	260,434.34	-585,157.90
7	Cr$			1,704,683.68	263,857.72	-576,377.35
8	Cr$			2,085,605.44	169,761.55	-541,316.03
9	Cr$			2,627,880.25	328,906.92	-526,772.77
10	Cr$			3,093,298.81	296,726.34	-550,930.87
11	Cr$			3,488,252.39	423,229.44	-577,565.99
12	Cr$			3,473,934.52	390,146.91	-671,147.19

occurs in the first year, but in the case of the 12th year, the restrictions are the hired laborers and the mule-power days shown in the shadow prices at the level of Cr $5.05 and of Cr $7.94 respectively.

The highest shadow price of the arable land occurs in the 8th year when all arable lands are occupied by the sugarcane activities. The level of the shadow price of land is Cr $969.56, for the same reason explained in the paragraph above.

If we consider the price of rent at approximately Cr $300.00 as before, the land could be increased in order to improve the net income because the shadow prices of the land per alqueire are fairly high except Cr $84.77 in the first year.

The shadow prices of the hired labor, November to April, are: Cr. $6.71, Cr $2.49 and Cr $5.05 in the first, 2nd and 12th years respectively. In the 2nd year the level of the hired labor of this period is zero, but the shadow price of the hired labor of this period is positive at the level of Cr $2.49. This occurs because the shadow prices in dynamic linear programming or in linear programming have some permissible ranges of levels of activity.

In the hired labor, May to October, the shadow prices of this labor are constant from the 2nd year to the 12th year at the level of Cr $5.05. However, the activity of the hired labor of this period varies during these years because of the characteristics of dynamic linear programming which permits some range of the activity variation for the specific shadow prices.

Table 72. Shadow prices for the resources--tractor type V Model

Year	Land per alqueire	Labor, November-April per day	Labor, May October per day	Tractor II per day	Tractor III per day	Mule per day	Capital per Cr$	Capital borrowing per Cr$
1	Cr$ 84.77	Cr$ 6.71			Cr$ 204.99		Cr$ .34	Cr$ .24
2	Cr$ 698.99	Cr$ 2.49	Cr$ 5.05		Cr$ 107.05		Cr$ .01	
3	Cr$ 848.56		Cr$ 5.05		Cr$ 87.59		Cr$ .01	
4	Cr$ 848.56		Cr$ 5.05		Cr$ 92.02		Cr$ .01	
5	Cr$ 848.56		Cr$ 5.05		Cr$ 54.69		Cr$ .01	
6	Cr$ 848.56		Cr$ 5.05		Cr$ 65.81		Cr$ .01	
7	Cr$ 848.56		Cr$ 5.05		Cr$ 33.66		Cr$ .01	
8	Cr$ 969.56		Cr$ 5.05				Cr$ .01	
9	Cr$ 848.56		Cr$ 5.05		Cr$ 224.01		Cr$ .01	
10	Cr$ 848.56		Cr$ 5.05		Cr$ 119.28		Cr$ .01	
11	Cr$ 848.56		Cr$ 5.05				Cr$ .01	
12	Cr$ 418.50	Cr$ 5.05	Cr$ 5.05			Cr$ 7.94	Cr$ .01	

The shadow price of the tractor type III varies from the highest level of Cr $224.01 in the 9th year to zero in the 8th, 11th and 12th years. Unfortunately, the present study has no price for the tractor type III to compare with the shadow prices which will indicate the expansion direction of the model.

The shadow price of the capital is Cr $.34 in the first year, which is fairly high in comparison with the interest rate. This introduces the capital borrowing activity into the system. From the 2nd year on the shadow price of the capital decreases to Cr $.01 and is maintained at the same level from the 2nd year to the 12th year.

Summary and analyses

In this model the tractor type II sugarcane activities are not entered into the solution at any level while the tractor type III sugarcane activities are. This justifies the scale economy found in the preceding research in the cost of production (17).

The level of the sugarcane activities in this model V is not so high in Model III because the number of available days of the tractor type III strongly restrict the sugarcane activities. This factor distinguishes this model from Model III as discussed previously. Further, the restriction of the tractor type III brings into the solution crop activities that do not need so many days of the tractor type III as do the sugarcane activities.

The hired labor, November to April, is not entered into the solution except in the first and 12th years. Again the number of tractor type III available days restricts the level of the hired labor in this period as well as in the sugarcane activity. The hired labor, May to October, has a constant shadow price from the 2nd year to the 12th year. However, the level of activity varies from 9,640 days in the 9th year to 5,728 days in the 12th year because of the linearity assumption of dynamic linear programming.

The model borrowed only in the first year; after the 2nd year there is not borrowing because the system itself is able to generate enough money for production finance in the following years. The capital is steadily increased from the 2nd year on. The net income is a negative figure in the first year, although all other years show all net incomes as positive. The overall net income in this model is Cr $3,275,244.90.

Tractor type VI Model

This final model, the tractor type VI, is composed of three combined models of tractor I, tractor II and tractor III Models of the sugarcane production activities.

The size of this model belongs to class IV of the size classification, between 1,501 and 2,000 tons.

The objective function value of this model has arrived at the level of Cr $281,719.73 over all 12 years.

Sugarcane activities

There are three types of tractor methods for the sugarcane production which are combined in this model. However, in the solution only one tractor type method is entered as can be seen in Table 73. This table shows that the greater horsepower tractor-method is more profitable than the smaller horsepower tractor-method in this size of model.

In the first year the cane-harvest-harvest activity enters into the solution at the level of 13.68 alqueires. This level continues until the 3rd year. From the 3rd year to the 9th year this activity is decreased to the zero level. In the 10th year this activity again appears at the level of 7.03 alqueires, since the 3-year cycle activity is supplementing the 4-year cycle activity. This can be seen in Table 73 because all other sugarcane activities are a 4-year cycle activity.

The cane-harvest-harvest-harvest activity is entered into the solution at the level of 27.38 alqueires in the first year. This level of activity is maintained through all years until the 12th year.

In the 2nd year the cane-harvest-harvest-harvest (B) is entered into the solution at the level of 7.03 alqueires. This 4-year cycle is repeated twice maintaining the same level and is terminated in the 9th year.

In the 4th year, again, the 4-year cycle activity of the cane-harvest-harvest-harvest (D) is entered into the solution at the level of 13.68 alqueires, which is maintained at the same level of the activity until the 11th year.

Of overall sugarcane production activities the 4-year cycle activity is the most profitable in this model. The second most

Table 73. Area of sugarcane--tractor type VI Model[a]

		Tractor type III												
													Output of sugarcane	
Year	Unit	Cane-harvest	Cane-harvest-harvest	Cane-harvest-harvest-harvest	Cane-harvest (B)	Cane-harvest-harvest (B)	Cane-harvest-harvest-harvest (B)	Cane-harvest-harvest (C)	Cane-harvest-harvest-harvest (C)	Cane-harvest-harvest-harvest (D)	Total of cane area	% of total area in cane	Unit	Total output
1	Alqueire		13.68	27.38							41.06	85		
2	Alqueire		13.68	27.38			7.03				48.08	100	ton	6,569
3	Alqueire		13.68	27.38			7.03				48.08	100	ton	6,461
4	Alqueire			27.38			7.03			13.68	48.08	100	ton	3,651
5	Alqueire			27.38			7.03			13.68	48.08	100	ton	2,891
6	Alqueire			27.38			7.03			13.68	48.08	100	ton	6,158
7	Alqueire			27.38			7.03			13.68	48.08	100	ton	6,051
8	Alqueire			27.38			7.03			13.68	48.08	100	ton	3,651
9	Alqueire			27.38			7.03			13.68	48.08	100	ton	2,891
10	Alqueire		7.03	27.38						13.68	48.08	100	ton	6,158
11	Alqueire		7.03	27.38						13.68	48.08	100	ton	6,051
12	Alqueire		7.03	27.38							34.41	72	ton	3,651
Total														54,183

[a](B), (C) and (D) first planted in the 2nd, 3rd and 4th years, respectively.

profitable production activity of the sugarcane is the 3-year cycle activity which is entered into the solution in the beginning years and in the final years of the model. This occurs as a result of the technical production difficulties of the sugarcane cycle over time. This 3-year cycle activity is used in order to supplement the technical difficulty of the 4-year cycle activities which are most profitable in this model.

Almost all available arable land areas are used for the sugarcane production in this model. From the 2nd year to the 11th year, the sugarcane production activities have occupied 100% of the available arable land. In the first year and the 12th year the available arable land is occupied by the sugarcane activities at the level of 41.06 alqueires and of 34.41 alqueires, which correspond to 85% and 72% of the land respectively.

The total production of the sugarcane ranges from the maximum production of 6,569 tons in the 2nd year to the minimum production of 2,891 tons in the 5th year and the 9th year. The optimum production level of the sugarcane is always above the level of the quota system allocation, as will be discussed later.

Crop activities

In the crop activities only cotton is entered into the solution at the level of 7.03 in the first year and at the level of 13.68 alqueires in the 12th year. It is entered into the solution in the beginning of all periods of the year and at the end of all periods of the

Table 74. Area of crop land--tractor type VI Model

Year	Unit	Cotton	Corn-animal	Corn-tractor	Rice	Total crop land	% of total areas in crop
1	Alqueire	7.03				7.03	15
2	Alqueire						
3	Alqueire						
4	Alqueire						
5	Alqueire						
6	Alqueire						
7	Alqueire						
8	Alqueire						
9	Alqueire						
10	Alqueire						
11	Alqueire						
12	Alqueire	13.68				13.68	28

year because of the technical difficulties of the sugarcane production. Though the profitability of the sugarcane is the highest, there exists the cyclical difficulty in using all available arable land at the beginning and ending of all period of years. Therefore, the cotton activity is entered into the solution in order to supplement this difficulty since this activity is the second most profitable one.

In percentage terms, the cotton activity in the first year occupies 15% and in the 12th year 28% of the total available arable land areas.

Hired labor activities

In this model the hired labor activity is entered into the solution at the positive level of 699 days only in the first year. However, the shadow prices of the hired labor appear in the first 5th and 9th years at the level of Cr $6.16, Cr $5.76 and Cr $1.98 respectively. This happens because the activities vary within some range at constant shadow prices.

The hired labor, May to October, has a zero level of the activity in the first, 5th and 9th years. In the first year there is no harvesting activity in the sugarcane production, placing the activity at the zero level. In the 5th and 9th years the hired labor activity is zero again; however, the shadow prices of these two years are Cr $5.76 and Cr $5.71 respectively. This means that these hired labor activity levels are within the range of these constant shadow prices even though the activity level of the hired labor is zero.

Table 75. Hired labor activities--tractor type VI Model

Year	Labor, November to April		Labor, May to October		Total hired labor/year	
	Day	Number of persons hired	Day	Number of persons hired	Day	Number of persons hired
1	699	4.7			699	2.3
2			1,595	10.6	1,595	5.3
3			1,536	10.2	1,536	5.1
4			321	2.1	321	1.1
5						
6			1,413	9.4	1,413	4.7
7			1,358	9.1	1,358	4.5
8			321	2.1	321	1.1
9						
10			1,413	9.4	1,413	4.7
11			1,358	9.1	1,358	4.5
12			663	4.4	663	2.2
Total	699		9.978		10,677	

The highest labor activity level is 1,595 days and the lowest labor activity level is 321 days in the 4th and in the 8th years. The number of workers employed constantly over this period vary greatly from the maximum number 11 to the minimum number 3, excluding the zero levels. Sometimes this variation creates problems from the administrative point of view. So, if a stabilized, constant level of the hired labor allocation is desired, (with some sacrifice of the net income level), some bounding procedures on the labor activity can be used. Then this problem will be solved.

Financial activities and net income and cash flow for each year

This model borrowed capital from outside the system at the level of Cr $33,999.59 in the first year in order to supplement the shortage of capital. However, after the 2nd year there is no positive borrowing activity, as the model generates its own necessary capital within the model by sugarcane and crop production.

In the first year there is no capital transfer because this period has a capital shortage for production. From the 2nd year on, the capital transfer increases steadily from the level of Cr $37,392.47 in the 2nd year to the level of Cr $553,751.49 in the 12th year.

At 3 points the net income of this model is negative: at the level of Cr $64,104.13, Cr $10,695.65 and Cr $10,695.65 in the first, 5th and 9th years, respectively. This is because the most important source

Table 76. Financial activities and net income and cash flow--tractor type VI Model

Year	Unit	Capital borrowing	Capital lending	Capital transfer	Net income	Cash flow
1	Cr$	33,999.59			-64,104.13	-79,025.69
2	Cr$			37,392.47	47,996.87	-70,304.33
3	Cr$			118,960.13	55,792.52	-60,573.33
4	Cr$			159,794.11	15,058.82	-50,695.42
5	Cr$			174,873.60	-10,695.65	-62,763.86
6	Cr$			243,165.56	42,516.80	-68,394.20
7	Cr$			319,210.07	50,269.36	-58,706.29
8	Cr$			360,044.04	15,058.82	-50,695.42
9	Cr$			375,123.54	-10,695.65	-62,963.86
10	Cr$			443,415.49	42,516.80	-68,394.20
11	Cr$			519,460.00	50,269.36	-58,706.29
12	Cr$			553,751.49	42,198.29	-57,237.91

of net income is based upon sugarcane production. In the first year there is no sugarcane production because of its technical difficulty which comes from the model. In the 5th and 9th years the net income is negative again because in these two years the sugarcane production is at the lowest level (Table 76). The highest net income is in the 3rd year at the level of Cr $55,792.52.

The cash flow is fairly constant over the 12 years from the maximum level of Cr $79,025.69 in the first year to the minimum level of Cr $50,695.42 in the 4th and 8th years.

Shadow prices

The shadow prices of the land are fairly high over 12 years comparing the price of rent of approximately Cr $300.00 in this region. The lowest shadow price of land is Cr $501.07 in the first year. Even though this is the lowest shadow price, it is higher than the rent price in this region. The highest shadow price of the land is Cr $990.99 which is more than three times higher than the price of rent. This means that the expansion of the land increases the net income to a rather high level. Unfortunately, the present study did not analyze this problem from the viewpoint of budget and time constraints.

In the hired labor, November to April, only 3 years' shadow prices have a positive result in the first, 5th and 9th years. However, in the real activity level only the first year comes out as a positive number at the level of 699 days. Other activities are entered at the level of zero.

Table 77. Shadow prices for the resources--tractor type VI Model

Year	Land per alqueire	Labor, November-April per day	Labor, May October per day	Tractor I per day	Tractor II per day	Tractor III per day	Capital per Cr$	Capital borrowing per Cr$
1	Cr$ 501.07	Cr$ 6.16					Cr$ .08	
2	Cr$ 982.09		Cr$ 5.76				Cr$ .01	
3	Cr$ 880.13		Cr$ 5.76				Cr$ .01	
4	Cr$ 990.99		Cr$ 5.76				Cr$ .01	
5	Cr$ 754.68	Cr$ 5.76	Cr$ 5.76				Cr$ .01	
6	Cr$ 924.52		Cr$ 5.76				Cr$ .01	
7	Cr$ 880.13		Cr$ 5.76				Cr$ .01	
8	Cr$ 874.18		Cr$ 5.76				Cr$ .01	
9	Cr$ 930.98	Cr$ 1.98	Cr$ 5.71				Cr$ .01	
10	Cr$ 905.29		Cr$ 5.76				Cr$ .01	
11	Cr$ 880.72		Cr$ 5.76				Cr$ .01	
12	Cr$ 830.89		Cr$ 5.76				Cr$ .01	

The hired labor period, May to October, has a fairly constant level of shadow prices, even though the activity level of the hired labor of this period varies at a somewhat high level from period to period and from year to year. The shadow prices are a little higher than the market price of Cr $5.70. Therefore, it cannot be expected that the net income be increased by the change or increase of the hired labor of this period.

The shadow price of the capital is Cr $.08 in the first year, a little higher than the market interest rate which is 7%. This is because the capital borrowing activity is entered at approximately the same level to equalize to 7%. From the 2nd to the 12th years the shadow price of the capital is the same at the level of Cr $.01 as shown in Table 77.

Summary and analyses

In this model the most profitable activities are the sugarcane activities. Over the 12 years (except the first year and the 12th year) all land areas are devoted to the sugarcane production. Further, this choice is most reasonable because the shadow prices of land are the highest compared with the shadow prices of the land areas not used completely by the sugarcane production (as in the first year and the 12th year which have the shadow prices of Cr $501.07 and of Cr $830.89 respectively). Among the sugarcane activities the 4-year cycle activity of the cane-harvest-harvest-harvest is the most profitable one. The second one is the cane-harvest-harvest activity, entered into the solution once only.

The crop activities have been entered into the solution and as supplementary functions of the very profitable sugarcane activities. Therefore, the cotton activity, the most profitable of the crop activities, is entered into the solution in the first and final years only.

Even though the quantity of variation of the hired labor activity is shown over all 12 years the shadow prices are fixed at almost the same level. This happens because there is enough capital to introduce hired labor, which reduces the shadow prices to an almost equal level with the market labor prices, i.e., wage level.

The capital transfer increases at a fairly steady rate to the maximum level of Cr $553,751.49 in the 12th year. The 12-year objective function value is Cr $281,719.73.

Quota System Results and Analyses

This section will present results of the quota system policy of I.A.A. (Institute of Alcohol and Sugar) to the sugarcane production and some comparisons between the standard efficiency results by the dynamic linear programming method and the impact on factor inputs, especially labor input of the institutional policy result.

Quota system--tractor type I Model

As described in the standard results, this model belongs to the class II category which supplies sugarcane from 501 tons to 1,000 tons, the quantity imposed on this farm by the government. This result will be shown in the following sections.

The objective function value, i.e., the net income, over all 12 years is Cr $50,829.32. This figure is compared with the result of the standard model having no government quota system restriction. This model had the value of Cr $91,825.55. As the above figures show the quota system reduced the overall net income by almost half. This is a significant result of the quota policy, which has not been studied by anyone. Of course, these analyses are presented under the efficiency allocation of the resources since the model has been described before under the specific assumptions of the model.

Sugarcane activities

Generally, the sugarcane planting area is reduced by the restriction of the quota as Table 78 shows. However, the distribution of the sugarcane area is flattened out over the whole 12 years. This means that without the quota system restriction, the production of the sugarcane has more variation from year to year. This variation in production of the sugarcane shows that when the technical characteristics of the sugarcane and the resource restriction permits more production increase, the model tries to attain the maximum level of the net income that is the objective function.

Each activity of the sugarcane area comparison is not discussed here because it is shown in Table 78, which is compared with Table 48.

The production of sugarcane is reduced from 17,379 to 11,000 tons by the quota system.

Table 78. Quota system--area of sugarcane--tractor type I Model[a]

Year	Unit	Cane-harvest	Cane-harvest-harvest	Cane-harvest-harvest-harvest	Cane-harvest (B)	Cane-harvest-harvest (B)	Cane-harvest-harvest-harvest (B)	Cane-harvest-harvest (C)	Cane-harvest-harvest-harvest (C)	Cane-harvest-harvest-harvest (D)	Total of cane area	% of total area in cane	Output of sugarcane: Unit	Output of sugarcane: Total output
1	Alqueire		6.67								6.67	29		
2	Alqueire		6.67				1.33				8.00	34	ton	1,000
3	Alqueire		6.67				1.33	3.11			11.11	48	ton	1,000
4	Alqueire		3.11				1.33	3.11		5.87	13.42	57	ton	1,000
5	Alqueire			1.97			1.33			5.87	9.17	39	ton	1,000
6	Alqueire			1.97			1.57			5.87	9.41	40	ton	1,000
7	Alqueire			1.97			1.57		4.23	5.87	13.64	58	ton	1,000
8	Alqueire			1.97		2.34	1.57		4.23		10.11	43	ton	1,000
9	Alqueire			2.26		2.34	1.57		4.23		10.40	45	ton	1,000
10	Alqueire		4.86	2.26		2.34			4.23		13.69	59	ton	1,000
11	Alqueire	1.42	4.86	2.26							8.54	37	ton	1,000
12	Alqueire	1.42	4.86	2.26							8.54	37	ton	1,000
														11,000

[a](B), (C) and (D) first planted in the 2nd, 3rd and 4th years, respectively.

Crop activities

In order to substitute for the reduction of sugarcane production with a minimum loss of net income, the alternative production activities, i.e., crop activities, in this model are introduced and with the higher level of activities compared with the result of the standard calculation. Without the quota system, only the cotton activity is entered into the solution. However, the result of the quota system is forcing the corn tractor activity into the solution at a fairly high level as shown in Table 79.

The distribution of land area of the total crop activities is fairly constant over 12 years ranging from the minimum of 41 in the 10th year to the maximum of 66 in the 2nd year in percentage terms.

Hired labor activities

The hired labor, November to April, is 2,157 days over all 12 years. This quantity is reduced from 7,953 days of the standard result. Further, the hired labor, May to October, is 942 days over all the 12-year requirement, which is tremendously reduced compared with the figure of the same period of the standard results, 5,599 days.

The impact of the quota system on the labor absorption is astonishingly strong on the simple labor market of this model. This is shown in the comparison of the hired-labor-per-year total between the standard result and the quota system result. In the standard result the hired-labor-per-year total had 13,552 days. However, this quantity is reduced to less than one-quarter by the result of the quota system policy (Tables 50 and 80).

Table 79. Quota system--area of crop land--tractor type I Model

Year	Unit	Cotton	Corn-animal	Corn-tractor	Rice	Total crop land	% of total areas in crop
1	Alqueire			13.71		13.71	59
2	Alqueire			15.34		15.34	66
3	Alqueire	1.74		10.49		12.23	52
4	Alqueire			9.92		9.92	43
5	Alqueire	2.91		11.26		14.17	61
6	Alqueire	1.31		12.62		13.93	60
7	Alqueire	1.70		8.00		9.70	42
8	Alqueire			13.22		13.22	57
9	Alqueire	4.55		8.40		12.95	55
10	Alqueire	.41		9.24		9.65	41
11	Alqueire	3.22		11.58		14.80	63
12	Alqueire	6.46		8.34		14.80	63

Table 80. Quota systems--hired labor activities--tractor type I Model

Year	Labor, November to April		Labor, May to October		Total hired labor/year	
	Day	Number of persons hired	Day	Number of persons hired	Day	Number of persons hired
1	238	1.6			238	.8
2	33	.2	191	1.3	224	.7
3	101	.7			101	.3
4	307	1.4	27	.2	254	.8
5	222	1.5	216	1.4	438	1.5
6	158	1.1	23	.2	181	.6
7	245	1.6			245	.8
8	79	.5	84	.6	163	.5
9	356	2.4	103	.7	459	1.5
10	180	1.2			180	.6
11	237	1.6	184	1.2	421	1.4
12	101	.7	114	.8	215	.7
Total	2,157		942		3,119	

Financial activities and net income and cash flow for each year

The capital borrowing activity is entered into the solution at the levels of Cr $2,691.47 and Cr $2,923.78 in the first year and 2nd year. The level of these activities is very low if compared with the result of the standard calculation: the no-quota system as has been shown in Table 81. This difference means that in order to increase the production of sugarcane, the model needs more capital and can pay for that capital if it is financed from outside the farm.

The capital transfer is decreased drastically in the number of years which are the solution and in the quantity level in comparison with the result of the standard calculation.

Under the quota system, the net income is more standardized as we can see in Table 81. Further, the negative net income appears in the solution only once, at the level of Cr $11,666.96 in the first year. However, in the standard model negative income appears in the solution twice. This indicates that even though the value of the objective function is attained at the higher level in the standard model, there is a big variation of the net income from year to year.

The quantity of the cash flow is reduced over all years when comparing to the result of the standard calculation since the sugarcane production has great influence on the cash flow, as seen in the model construction.

Table 81. Quota system--financial activities and net income and cash flow--tractor type I Model

Year	Unit	Capital borrowing	Capital lending	Capital transfer	Net income	Cash flow
1	Cr$	2,691.47			-11,666.96	-23,821.44
2	Cr$	2,923.78			4,286.85	-27,324.48
3	Cr$				7,587.96	-24,152.13
4	Cr$			2,886.59	2,542.02	-24,393.98
5	Cr$				5,140.38	-30,167.16
6	Cr$				5,318.71	-27,280.57
7	Cr$			1,967.20	4,089.64	-25,313.37
8	Cr$			3,580.39	4,247.05	-25,667.38
9	Cr$				5,906.29	-30,860.96
10	Cr$			3,439.50	3,499.14	-23,841.07
11	Cr$				5,641.92	-30,720.07
12	Cr$				14,144.68	-27,280.57

Shadow prices

With the result of the quota system, the land is no more scarce than in the standard model. The shadow prices of land are always less than the market rent value if the price of rent per alqueire is considered Cr $300.00 as before. The sugarcane production is a more land-consuming method than the crop activities.

The shadow prices of the hired labor are increased somewhat in the quota system over all 12 years. This means that even though the total level of the hired-labor activities are reduced, the newly introduced activities, such as the crop activities, require more labor for their operation.

The shadow prices of the capital are increased in the quota system; the crop activities which are newly entered into the solution are more capital-consuming activities compared with the sugarcane activities.

Quota system--tractor type II Model

This model belongs to class V as described in the model construction. The size of the available land area is smaller in this model, compared with the class IV model, because when the constraints in the model were constructed, the figures of the constraints of all models were taken from the arithmetic means of production-cost research. Further, the farmers who were sampled by the questionnaires have not always organized their farms in an efficient way in the sense of maximizing the net income, as done in the present study. This is the reason the size of

Table 82. Quota system--shadow prices for the resources--tractor type I Model

Year	Land per alqueire	Labor, November-April per day	Labor, May-October per day	Tractor I per day	Mule per day	Capital per Cr$
1	Cr$	Cr$	Cr$ 7.11			Cr$ .48
2	Cr$ 34.95	Cr$ 6.85	Cr$ 6.65			Cr$ .38
3	Cr$ 102:21	Cr$ 6.21	Cr$ 3.25			Cr$ .29
4	Cr$ 123.09	Cr$ 5.97	Cr$ 5.97			Cr$ .24
5	Cr$ 123.09	Cr$ 5.97	Cr$ 5.97			Cr$ .24
6	Cr$ 123.09	Cr$ 5.97	Cr$ 5.97			Cr$ .24
7	Cr$ 123.09	Cr$ 5.97	Cr$ 5.97			Cr$ .24
8	Cr$ 123.09	Cr$ 5.97	Cr$ 5.97			Cr$ .24
9	Cr$ 123.09	Cr$ 5.97	Cr$ 5.97			Cr$ .24
10	Cr$ 123.09	Cr$ 5.97	Cr$ 5.97			Cr$ .24
11	Cr$ 123.09	Cr$ 5.97	Cr$ 5.97			Cr$ .24
12	Cr$ 123.09	Cr$ 5.97	Cr$ 5.97			Cr$ .24

available land is not correlated with the quota system level, even though the sugarcane production has high correlation with land area, as seen in the previous analyses.

The objective function value over all 12 years is greatly reduced to Cr $97,672.42 from Cr $264,797.63, the result of the standard calculation. As presented above the standard result of this model showed a very high figure because of the lending activity that brought tremendous profit into the model. Without the lending activity this model receives only Cr $98,833.01 which is at almost the same level as the result in the quota.

Sugarcane activities

In the quota system, the cane-harvest-harvest-harvest (C) activity is first entered into the solution at the level of 12.50 alqueires in the 3rd year and of 1.64 alqueires in the 7th year in the first and 2nd 4-year cycles, respectively. This entrance of the new activity into the solution is not interpreted as the increase of the planting area of the sugarcane production, since, as can be seen in Table 83, the overall sugarcane production areas are reduced by the quota system.

In percentage terms, in the standard solution, the sugarcane areas accept 100% of the total area in the sugarcane from the 2nd year to the 11th year, excluding the first year, with 77% of the sugarcane area, and the 12th year with 68% of the sugarcane area. In the new solution of the quota system the area occupied by sugarcane production varies from the maximum of 88% in the 3rd year to the minimum of 46% in the first year.

Table 83. Quota system--area of sugarcane--tractor type II Model[a]

Year	Unit	Cane-harvest	Cane-harvest-harvest	Cane-harvest-harvest-harvest	Cane-harvest (B)	Cane-harvest-harvest (B)	Cane-harvest-harvest-harvest (B)	Cane-harvest-harvest (C)	Cane-harvest-harvest-harvest (C)	Cane-harvest-harvest-harvest (D)	Total of cane area	% of total area in cane	Output of sugarcane	
													Unit	Total output
1	Alqueire			21.43							21.43	46		
2	Alqueire			21.43			7.65				29.08	61	ton	3,000
3	Alqueire			21.43			7.65		12.50		41.58	88	ton	3,000
4	Alqueire			7.01			7.65		12.50	5.76	32.92	70	ton	3,000
5	Alqueire			6.25			7.65		12.50	5.76	32.16	69	ton	2,543
6	Alqueire			6.25			14.12		12.50	5.76	38.63	82	ton	2,393
7	Alqueire			6.25			14.12		1.64	5.76	27.77	59	ton	3,000
8	Alqueire			6.25			14.12		1.64	5.22	27.23	58	ton	2,001
9	Alqueire			17.13			14.12		1.64	5.22	38.11	81	ton	2,008
10	Alqueire		7.00	17.13					1.64	5.22	30.99	66	ton	3,000
11	Alqueire		7.00	17.13						5.22	29.35	62	ton	2,940
12	Alqueire		7.00	17.13							24.13	51	ton	2,001
Total														28,886

[a](B), (C) and (D) first planted in the 2nd, 3rd and 4th years, respectively.

The output of the sugarcane is reduced to a fairly low level. In the overall 12-year total, the quota system solution produces 28,886 tons. However in the standard solution, the total output of the overall 12 years was 41,690 tons. The difference is 12,804 tons, which is almost half the standard result.

Crop activities

In the crop activities, cotton and rice are entered into the solution in the quota system. The cotton activity maintains a relatively high level of the land areas through all 12 years, varying from the maximum of 22.89 alqueires in the 12th year to the minimum of 5.45 alqueires in the 3rd year. The second most profitable crop activity, rice, is entered into the solution at the level of 2.99 alqueires in the first year. However, this rice activity is in the solution only once in the first year.

The percentage of the crop land area is constantly maintained in comparison to the crop land area of the standard solution. The highest percentage of the crop land occupied is 50 in the first year and the lowest percentage is 12 in the 3rd year.

In the standard solution, seen in Table 54, the cotton activity is entered into the solution only once, at the level of 14.91 alqueires in the 12th year. The difference in the crop activity levels between the standard solution and the quota system solution is tremendous.

Table 84. Quota system--area of crop land--tractor type II Model

Year	Unit	Cotton	Corn-animal	Corn-tractor	Rice	Total crop land	% of total areas in crop
1	Alqueire	20.54			2.99	23.53	50
2	Alqueire	17.95				17.95	39
3	Alqueire	5.45				5.45	12
4	Alqueire	14.11				14.11	30
5	Alqueire	14.87				14.87	31
6	Alqueire	8.40				8.40	18
7	Alqueire	19.26				19.26	41
8	Alqueire	19.79				19.79	42
9	Alqueire	8.91				8.91	19
10	Alqueire	16.03				16.03	34
11	Alqueire	17.67				17.67	38
12	Alqueire	22.89				22.89	49

Hired labor activities

The hired labor activities are expected to be reduced by the quota system in this model. However, as seen in the comparison between Table 55 and Table 85, the hired labor quantity is increased by the quota system. This is because the model substituted for the sugarcane activities the second most profitable activities, primarily, cotton a more labor-absorbing activity compared to sugarcane, which is a more land-absorbing process. Through an efficient mathematical model, the model has chosen the most profitable activities, considering the restraints of the available resources. However, this choice of mechanism does not work in the State of Sao Paulo, Brazil. Usually, in the short run, the impact of the sugarcane under the quota system accelerates migration from the rural area to the urban areas, since there is no adequate recommendation given to the farmers to try to find other alternative enterprises that approach the higher net income level of sugarcane. In the near future these difficult points may be solved by new researchers.

Financial activities and net income and cash flow for each year

In this model the capital borrowing activity is entered into the solution at the levels of Cr $14,508.95 and Cr $17,694.45 in the first and 2nd years, respectively, as shown in Table 86. The entrance of capital borrowing into the solution is compared with the result of the standard calculation which has no capital borrowing activity at any level.

Table 85. Quota system--hired labor activities--tractor type II Model

Year	Labor, November to April		Labor, May to October		Total hired labor/year	
	Day	Number of persons hired	Day	Number of persons hired	Day	Number of persons hired
1	1,694	11.3			1,694	5.6
2	1,178	7.9	821	5.5	1,999	6.7
3	492	3.3	508	3.4	1,000	3.3
4	820	5.5	725	4.8	1,545	5.2
5	841	5.6	470	3.1	1,311	4.4
6	680	4.5	218	1.5	898	3.0
7	932	6.2	853	5.7	1,785	6.0
8	1,021	6.8	267	1.8	1,288	4.3
9	726	4.8			726	2.4
10	1,055	7.0	773	5.2	1,838	6.1
11	853	5.7	778	5.2	1,631	5.4
12	539	3.6	345	2.3	884	2.9
Total	10,831		5,758		16,589	

The capital lending activity is zero in the quota system, even though it has very high competition in the standard solution. It may be interpreted that the level of output of sugarcane is highly correlated with the lending activity and that the capital lending activity is competing with the capital transfer activity.

The capital transfer activity is entered into the solution from the 4th to 8th years and again in the 10th and 11th years. Other years remain at the zero level. In the standard solution the capital transfer activity is zero over all years. One interpretation of this phenomenon is that the capital transfer competes with the capital lending activity, having a high correlation with the level of the sugarcane output. However, this interpretation is still doubtful. Therefore, further analyses are expected to be made.

The net income is negative three times at the levels of Cr $29,334.56, Cr $992.61, and Cr $6,055.39 in the first, 6th and 9th years, respectively. In the standard solution the negative net income appears only once, in the first year at the level of Cr $59,805.47. This difference occurs because the output of the sugarcane is lowered by the quota system, and an activity related to the sugarcane output, the capital lending activity, drops out of the solution. These results are derived under the assumption that the computer executed the correct calculation.

The cash flow quantity of the quota system solution is tremendously reduced, primarily by the disappearance of the lending activity from the

Table 86. Quota system--financial activities and net income and cash flow--tractor type II Model

Year	Unit	Capital borrowing	Capital lending	Capital transfer	Net income	Cash flow
1	Cr$	14,508.95			-29,334.56	-83,374.74
2	Cr$	17,694.45			13,913.28	-83,075.96
3	Cr$				5,466.44	-61,973.03
4	Cr$			7,245.21	15,108.39	-73,660.88
5	Cr$			7,413.13	9,910.83	-72,515.05
6	Cr$			12,610.55	-992.61	-64,774.46
7	Cr$			14,726.02	22,665.62	-78,790.61
8	Cr$			1,117.34	8,259.39	-76,522.78
9	Cr$				-6,055.39	-64,171.88
10	Cr$			1,357.06	13,951.06	-79,549.03
11	Cr$			4,976.90	20,260.45	-76,210.07
12	Cr$				24,521.12	-67,891.00

solution. The reduction of the sugarcane activity level assumes that the crop activities have been substituted in the quantity of the cash flow.

Shadow prices

The shadow prices of the land in the quota system are reduced in the early years and are more standardized over all years. This happens because the more profitable sugarcane activities are reduced, giving higher shadow prices for the land, and the available lands are shifted to the less profitable crop activities that consume more hired labor.

The shadow prices for the hired laborers are less than the shadow prices for the hired laborers in the standard solution. Even though the more labor-consuming crop activities are entered into the solution in the quota system model, the absolute quantity is less than in the case of the sugarcane activities of the standard solution. This is true when the lending activity is combined with the sugarcane activities as shown in the standard model. Further, this phenomenon explains the difference between the shadow prices of the capital of the standard solution and of the quota system solution as compared in Tables 57 and 87.

Quota system--tractor type III Model

The tractor type III model belongs to class VIII, which should produce more than 10,000 tons by the quota system policy. As seen in the results of the standard calculation in the tractor type III model, output of the sugarcane satisfies the requirement of this classification. Therefore, the presentation of this model is excluded. That is, the results are the same as the results of the standard calculation.

Table 87. Quota system--shadow prices for the resources--tractor type II Model

Year	Land per alqueire	Labor, November-April per day	Labor, May-October per day	Tractor II per day	Mule per day	Capital per Cr$
1	Cr$	Cr$ 4.28		Cr$ 94.65	Cr$ 1.50	Cr$ .22
2	Cr$ 437.23	Cr$ 4.00	Cr$ 4.00			Cr$ .14
3	Cr$ 569.72	Cr$ 3.74	Cr$ 3.74			Cr$ .07
4	Cr$ 573.90	Cr$ 3.73	Cr$ 3.73			Cr$ .07
5	Cr$ 573.90	Cr$ 3.73	Cr$ 3.73			Cr$ .07
6	Cr$ 573.90	Cr$ 3.73	Cr$ 3.73			Cr$ .07
7	Cr$ 603.94	Cr$ 3.73	Cr$ 3.73			Cr$ .07
8	Cr$ 573.90	Cr$ 3.73	Cr$ 3.73			Cr$ .07
9	Cr$ 574.35	Cr$ 3.73	Cr$ 3.72			Cr$ .07
10	Cr$ 574.09	Cr$ 3.73	Cr$ 3.73			Cr$ .07
11	Cr$ 574.09	Cr$ 3.73	Cr$ 3.73			Cr$ .07
12	Cr$ 574.09	Cr$ 3.73	Cr$ 3.73			Cr$ .07

However, the quota system leaves a serious problem here to solve in future research. This problem is that of income distribution. If the quota system continues to maintain the same policy, there arises the problem of the large farmers always getting the efficiency allocation of the resources as if there were no quota system. And this matter increases the discrepancy in the income distribution. Therefore the quota system policy should be seriously considered in the immediate future under the government authority.

Quota system--tractor type IV Model

This model belongs to class IV, with output ranging from 1,501 tons to 2,000 tons of sugarcane by the determination of the quota system. This restriction is imposed on Model IV.

The objective function value of the tractor type IV in the quota system is Cr $105,141.00. This value is half the objective function of the same model with no constraints of the quota system, which had Cr $210,742.63 over all 12 years. The total net income is reduced to half the standard solution. This reduction of income comes primarily from the decrease of the sugarcane production by the quota policy.

Sugarcane activities

In the standard solution the sugarcane production is done primarily by the tractor type I. Only one activity of the tractor type II, which is the cane-harvest-harvest, is entered into the solution in the standard model. However, in the quota system model, the entrance of the

Table 88. Quota system--area of sugarcane--tractor type IV Model[a]

		Tractor type I								
Year	Unit	Cane-harvest	Cane-harvest-harvest	Cane-harvest-harvest-harvest	Cane-harvest (B)	Cane-harvest-harvest (B)	Cane-harvest-harvest-harvest (B)	Cane-harvest-harvest (C)	Cane-harvest-harvest-harvest (C)	Cane-harvest-harvest-harvest (D)
1	Alqueire			1.17						
2	Alqueire			1.17						
3	Alqueire			1.17				7.41		
4	Alqueire							7.41		1.94
5	Alqueire			4.46				7.41		1.94
6	Alqueire			4.46			8.61			1.94
7	Alqueire			4.46			8.61		3.77	1.94
8	Alqueire			4.46			8.61		3.77	5.15
9	Alqueire			6.95			8.61		3.77	5.15
10	Alqueire			6.95					3.77	5.15
11	Alqueire			6.95						5.15
12	Alqueire			6.95						

[a](B), (C) and (D) are first planted in the 2nd, 3rd and 4th years, respectively.

Table 88. Continued

		Tractor type II												
													Output of sugarcane	
Year	Unit	Cane-harvest	Cane-harvest-harvest	Cane-harvest-harvest-harvest	Cane-harvest (B)	Cane-harvest-harvest (B)	Cane-harvest-harvest-harvest (B)	Cane-harvest-harvest (C)	Cane-harvest-harvest-harvest (C)	Cane-harvest-harvest-harvest (D)	Total of cane area	% of total area in cane	Unit	Total output
1	Alqueire			13.02							14.99	30		
2	Alqueire			13.02	4.90						19.09	40	ton	2,000
3	Alqueire			13.02	4.90						26.50	55	ton	2,000
4	Alqueire									12.21	21.56	45	ton	2,000
5	Alqueire									12.21	26.02	54	ton	2,000
6	Alqueire									12.21	27.22	57	ton	2,000
7	Alqueire										18.78	39	ton	2,000
8	Alqueire										21.99	46	ton	2,000
9	Alqueire										24.48	51	ton	2,000
10	Alqueire		5.02								20.89	43	ton	2,000
11	Alqueire	6.59	5.02								23.71	49	ton	2,000
12	Alqueire	6.59	5.02								18.56	39	ton	2,000
Total														22,000

tractor type II into the solution is increased to five activities: the cane-harvest at the level of 6.59 alqueires; the cane-harvest-harvest at the level of 5.02 alqueires; the cane-harvest-harvest-harvest at the level of 13.02 alqueires; the cane-harvest (B) at the level of 4.90 alqueires; and the cane-harvest-harvest-harvest (D) at the level of 12.21 alqueires in the 11th, 10 11th, 10th, first, 2nd and 4th years, respectively.

The overall sugarcane area is reduced to a fairly low level as seen in the column of the percentage of total area in cane in Table 89.

The total output of the overall 12 years is reduced to 22,000 tons from 34,956 tons which it had in the standard solution. This is the primary source of the reduction of the net income in the quota system model.

Crop activities

With the quota system the area of the sugarcane is reduced, and the area of the crop lands is increased in the solution. This causes the land not to be so scarce a resource. Rather, in order to maintain high net income over all 12 years, the model introduces a corn tractor activity that consumes less labor and capital. Even though the cotton activity reduces its absolute quantity of the land area over all 12 years, the total crop land is increased by the entrance of the corn-tractor activity shown in Table 89.

Hired labor activities

In absolute numbers, the number of hired labor days is tremendously reduced, to 2,525 days in this quota system from 23,274 days in the standard solution. This occurs since, under the quota system, the

Table 89. Quota system--area of crop land--tractor type IV Model

Year	Unit	Cotton	Corn-animal	Corn-tractor	Rice	Total crop land	% of total areas in crop
1	Alqueire	3.85				3.85	8
2	Alqueire	5.82				5.82	12
3	Alqueire	5.98		15.59		21.57	45
4	Alqueire	6.38		12.73		19.11	40
5	Alqueire	3.30		18.76		22.06	46
6	Alqueire	6.21		14.66		20.87	43
7	Alqueire	3.68		25.63		29.31	61
8	Alqueire	3.62		22.48		26.10	54
9	Alqueire	5.67		17.93		23.60	49
10	Alqueire	4.98		22.20		27.18	57
11	Alqueire	6.55		17.82		24.37	51
12	Alqueire	15.52		14.00		29.52	61

Table 90. Quota system--hired labor activities--tractor type IV Model

Year	Labor, November to April		Labor, May to October		Total hired labor/year	
	Day	Number of persons hired	Day	Number of persons hired	Day	Number of persons hired
1						
2			119	.8	119	.4
3			136	.9	136	.5
4	202	1.3	181	1.2	283	1.3
5	15	.1	166	1.1	181	.6
6	295	2.0	215	1.4	510	1.7
7			209	1.4	209	.7
8	74	.5			74	.2
9	220	1.5	91	.6	311	1.
10			162	1.1	162	.5
11	137	.9			137	.5
12			303	2.0	303	1.
Total	943		1,582		2,525	

model has chosen activities such as the corn-tractor activity that consumes less labor force.

It is interesting to consider why the shadow price of the hired labor is higher than the result of the standard calculation. It seems that the capital is very much constrained which causes the relationship with the hired labor that is paid with wages through the capital row. Therefore, the shadow price of the hired labor is stopped at the high level, compared with the market wage. Further, this is because of quota-system restriction.

Financial activities and net income and cash flow for each year

The capital borrowing activity is entered into the solution at the level of Cr $17,365.22 in the first year and at the level of Cr $6,860.23 in the 2nd year. These two figures are less than one-fourth of the level of the capital borrowing activity in the standard solution.

Capital transfer is entered into the solution at a fairly low level in the 6th, 8th, 9th, 10th and 11th years, as Table 91 shows. In the standard solution the capital transfer is entered into the solution at a positive level continuously from the 4th year to the 11th year. The absolute level of the latter is very high compared with that of the quota system solution.

The net income figures are negative at the level of Cr $35,017.88 in the first year and of Cr $340.82 in the 2nd year consecutively. However, from the 3rd year on all the net income figures turn out positive. This is compared with the results of the standard calculation, which shows a negative sign in the first year, in the 6th year

Table 91. Quota system--financial activities and net income and cash flow--tractor type IV Model

Year	Unit	Capital borrowing	Capital lending	Capital transfer	Net income	Cash flow
1	Cr$	17,365.22			-35,017.88	-43,282.67
2	Cr$	6,860.23			-340.82	-50,216.89
3	Cr$				10,179.49	-54,597.01
4	Cr$				1,261.74	-61,937.45
5	Cr$				5,770.14	-61,937.45
6	Cr$			1,005.99	3,578.81	-60,931.45
7	Cr$				5,195.32	-62,943.45
8	Cr$			1,695.97	4,912.64	-60,241.48
9	Cr$			2,141.66	4,626.12	-61,491.76
10	Cr$			1,053.10	5,252.27	-63,026.02
11	Cr$			661.75	5,865.42	-62,328.80
12	Cr$				24,233.59	-62,599.20

and in the 9th year. This shows that although the standard solution has a high absolute level of the net income, there is great variation in the values over time. It could be said that the quota system brings more stabilized net income.

The cash flow maintains an almost constant level over all 12 years. The absolute level of quantity of the cash flow each year is reduced. However, the reduction of the quantity of the cash flow is relatively high in comparison to the reduction of the land-need level by the quota system, because the shadow price of the capital remains at a high level.

Shadow prices

The shadow prices of the land under the quota system are very low; the value of the land through this model is reduced as compared to that of the standard solution. This happens because the more profitable sugarcane production activities, which consume more land in relative terms, are reduced and the lands are shifted to the other crop activities that are less profitable than the sugarcane activities.

In the hired labor, the shadow prices are fairly high over all 12 years, excluding the first to the 3rd years of November to April and the first year of May to October, perhaps due to the shortage of capital and quota-system restriction.

The shadow price of capital is high in the beginning years. From the 4th year on, the value of the shadow price of capital is reduced to Cr $.31 and remains at the same level until the 12th year. This price is very high, almost 10 times higher than the shadow price of the standard solution.

Table 92. Quota system--shadow prices for the resources--tractor type IV Model

Year	Land per alqueire	Labor, November-April per day	Labor, May October per day	Tractor I per day	Tractor II per day	Mule per day	Capital per Cr$
1		Cr$ 1.90					Cr$ .59
2		Cr$ 1.98	Cr$ 5.96				Cr$ .49
3	Cr$ 41.28	Cr$ 3.85	Cr$ 5.57				Cr$ .39
4	Cr$ 86.02	Cr$ 5.24	Cr$ 5.24				Cr$ .31
5	Cr$ 88.38	Cr$ 5.24	Cr$ 5.24				Cr$ .31
6	Cr$ 88.38	Cr$ 5.24	Cr$ 5.24				Cr$ .31
7	Cr$ 88.38	Cr$ 5.24	Cr$ 5.24				Cr$ .31
8	Cr$ 88.38	Cr$ 5.24	Cr$ 5.24				Cr$ .31
9	Cr$ 88.38	Cr$ 5.24	Cr$ 5.24				Cr$ .31
10	Cr$ 88.38	Cr$ 5.24	Cr$ 5.24				Cr$ .31
11	Cr$ 88.38	Cr$ 5.24	Cr$ 5.24				Cr$ .31
12	Cr$ 88.38	Cr$ 5.24	Cr$ 5.24				Cr$ .31

Quota system--tractor type V Model

This model is omitted here for the same reason as given for Model III. The quota system is satisfied in this model at the same level as that of the standard solution, as presented previously.

Quota system--tractor type VI Model

This model belongs to class IV, the output of which ranges from 1,501 tons to 2,000 tons. So in this quota system the bounds are imposed above range on the standard model.

The objective function value, i.e., the net income over all 12 years, is Cr $116,580.41. This value is less than half of the net income of the standard calculation result, Cr $281,719.73. This reduction of the net income is based primarily on the decrease of the sugarcane production by the quota system. The total output of the sugarcane is reduced to 22,000 tons over all 12 years from the 54,183 tons of the standard calculation a quantity more than two times greater.

Sugarcane activities

In the quota system the number of the sugarcane activities in the solution is increased compared with those of the standard solution. These new sugarcane activities are the cane-harvest-harvest (B) of the tractor type I at the level of 1.65 alqueires in the 3rd year, which is maintained at the same level until the 5th year, and the cane-harvest of the tractor type III at the level of 2.48 alqueires in the 11th year which is maintained at the same level until the 12th year, the

Table 93. Quota system--area of sugarcane--tractor type VI Model[a]

		Tractor type I								Tractor type II								
Year	Unit	Cane-harvest	Cane-harvest-harvest	Cane-harvest-harvest-harvest	Cane-harvest (B)	Cane-harvest-harvest (B)	Cane-harvest-harvest (C)	Cane-harvest-harvest-harvest (C)	Cane-harvest-harvest-harvest (D)	Cane-harvest	Cane-harvest-harvest	Cane-harvest-harvest-harvest	Cane harvest (B)	Cane-harvest-harvest (B)	Cane-harvest-harvest-harvest (B)	Cane-harvest-harvest (C)	Cane-harvest-harvest-harvest (C)	Cane-harvest-harvest-harvest (D)
1	Alqueire																	
2	Alqueire																	
3	Alqueire						1.65											
4	Alqueire						1.65											
5	Alqueire						1.65											
6	Alqueire																	
7	Alqueire																	
8	Alqueire																	
9	Alqueire																	
10	Alqueire																	
11	Alqueire																	
12	Alqueire																	

[a](B), (C) and (D) first planted in the 2nd, 3rd and 4th years, respectively.

Table 93. Continued.

		Tractor type III											
												Output of sugarcane	
Year	Unit	Cane-harvest	Cane-harvest-harvest	Cane-harvest-harvest-harvest	Cane harvest (B)	Cane-harvest-harvest (B)	Cane-harvest-harvest-harvest (B)	Cane-harvest-harvest (C)	Cane-harvest-harvest-harvest (C)	Cane-harvest-harvest-harvest (D)	Total of cane area	% of total area in cane	Unit	Total output
1	Alqueire			12.50							12.50	26		
2	Alqueire			12.50			2.34				14.84	31	ton	2,000
3	Alqueire			12.50			2.34				16.49	34	ton	2,000
4	Alqueire			12.50			2.34			11.04	27.53	57	ton	2,000
5	Alqueire			3.53			2.34			11.04	18.55	39	ton	2,000
6	Alqueire			3.53			2.73			11.04	17.80	36	ton	2,000
7	Alqueire			3.53			2.73		8.07	11.04	25.37	53	ton	2,000
8	Alqueire			3.53		4.23	2.73		8.07		18.56	39	ton	2,000
9	Alqueire			4.01		4.23	2.73		8.07		19.04	40	ton	2,000
10	Alqueire		9.24	4.01		4.23			8.07		25.55	53	ton	2,000
11	Alqueire	2.48	9.24	4.01							15.73	33	ton	2,000
12	Alqueire	2.48	9.24	4.01							15.73	33	ton	2,000
Total														22,000

cane-harvest-harvest (B) of the tractor type III at the level of 4.23 alqueires in the 8th year which is maintained at the same level until the 10th year and the cane-harvest-harvest-harvest (C) of the tractor type III at the level of 8.07 alqueires in the 7th year which is maintained at the same level until the 10th year.

With these modifications of the sugarcane activities the total arable area in sugarcane is reduced to less than half that of the standard calculation result compared in Table 73 and Table 93. Naturally, this reduction of sugarcane area decreases the output of sugarcane to less than half that of the standard calculation. Consequently, as referred to in the net income, the objective function of this model is drastically decreased.

Crop activities

In the crop activities, cotton, corn-tractor and rice are entered into the solution. The cotton activity maintains a positive activity level over all 12 years. The corn-tractor activity is entered into the solution at a positive level in the 3rd year, and this positive level of the activity is maintained until the 12th year. The rice activity is entered into the solution at the level of 1.20 alqueires in the first year only.

In the comparison of the crop land area with the area of the standard solution, it increases tremendously. In the standard solution only the cotton activity is entered into the solution, at the level of 7.03 alqueires in the first year and 13.68 alqueires in the

Table 94. Quota system--area of crop land--tractor type VI Model

Year	Unit	Cotton	Corn-animal	Corn-tractor	Rice	Total crop land	% of total areas in crop
1	Alqueire	8.21			1.20	9.41	20
2	Alqueire	12.83				12.83	27
3	Alqueire	11.02		11.87		22.89	48
4	Alqueire	9.76		9.15		18.91	39
5	Alqueire	12.00		11.37		23.37	49
6	Alqueire	11.90		9.42		21.32	44
7	Alqueire	10.47		12.24		22.71	47
8	Alqueire	11.70		11.17		22.87	48
9	Alqueire	11.84		4.26		16.10	33
10	Alqueire	10.26		12.26		22.52	47
11	Alqueire	11.78		20.56		32.34	67
12	Alqueire	15.49		14.73		30.22	63

12th year. This change comes from the reduced arable land areas under the quota system of sugarcane that shifted the land to the crop land areas in order to maintain the maximum possible net income in the dynamic linear programming framework.

Hired labor activities

The hired labor in the quota system is entered into the solution only once, at the very low level of 52 days in the 12th year during harvesting period of labor.

The impact of hired labor under the quota system is tremendous in this model. The reduction of the hired-labor requirement is from 10,677 days in the standard solution to only 52 days. This decrease carries from the increase of the crop activities that do not require as many laborers as do the sugarcane activities.

The result is shown in Table 95.

Financial activities and net income and cash flow for each year

The capital borrowing activity is entered into the solution only once, in the first year as in the standard solution. But the level of the activity is very low, compared with that of the standard solution of Cr $33,999.59 because the standard model makes more profit from the borrowing capital than does the quota system.

The capital transfer is entered into the solution in only 4 years: in the 3rd, 5th, 9th and 10th years. In the case of the standard solution the capital transfer is entered into the solution from the 2nd year on to the 12th year, at a rather high level.

Table 95. Quota system--hired labor activities--tractor type VI Model

	Labor, November to April		Labor, May to October		Total hired labor/year	
Year	Day	Number of persons hired	Day	Number of persons hired	Day	Number of persons hired
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12			52	.3	52	.2

Tabl 96. Quota system--financial activities and net income and cash flow--tractor type VI Model

Year	Unit	Capital borrowing	Capital lending	Capital transfer	Net income	Cash flow
1	Cr$	5,731.86			-29,148.94	-50,757.96
2	Cr$				11,960.34	-55,662.06
3	Cr$			1,810.89	13,864.44	-59,984.26
4	Cr$				6,841.85	-63,606.04
5	Cr$				14,017.75	-61,795.15
6	Cr$			784.24	12,793.45	-61,010.91
7	Cr$				10,238.19	-62,579.39
8	Cr$				13,079.52	-61,795.15
9	Cr$			5,727.45	10,782.41	-56,067.70
10	Cr$			4,962.75	9,755.43	-62,559.85
11	Cr$				16,776.44	-66,757.90
12	Cr$				25,620.56	-61,795.15

The net income is negative in the first year in this quota system. However, in the standard solution negative net income appears three times, even though the total overall net income is very high compared with the standard solution net income. This means that the standard solution has greater variation of the net income from year to year than does the quota system.

The volume of the cash flow between the standard solution and the quota system is greatly different because the cotton activity is a more capital-consuming activity than other activities, even though it makes more profit for the objective function. This problem can be seen clearly in the shadow prices of the capital, which are relatively high in the quota system.

Shadow prices

Land is not a scarce resource in the quota system since the shadow price is zero over all 12 years. Further, the shadow prices of the hired labor are very low as compared with the market price of the hired labor, Cr $5.70 in this quota model. This shows the increase of the corn-tractor activity that requires the smallest labor level for its operation.

Compared with the standard solution, the shadow price of the capital is fairly high over all 12 years, as the crop activities are relatively large capital-consuming activities, as opposed to the sugarcane activities.

Table 97. Quota system--shadow prices for the resources--tractor type VI Model

Year	Land per alqueire	Labor, November-April per day	Labor, May October per day	Tractor I per day	Tractor II per day	Tractor III per day	Mule per day	Capital per Cr$
1	Cr$	Cr$ 1.02						Cr$ .63
2	Cr$	Cr$ 3.64						Cr$ .52
3	Cr$	Cr$ 4.38						Cr$ .49
4	Cr$	Cr$ 4.38						Cr$ .49
5	Cr$	Cr$ 4.38						Cr$ .49
6	Cr$	Cr$ 4.38						Cr$ .49
7	Cr$	Cr$ 4.38						Cr$ .49
8	Cr$	Cr$ 4.38						Cr$ .49
9	Cr$	Cr$ 4.38						Cr$ .49
10	Cr$	Cr$ 4.38						Cr$ .49
11	Cr$	Cr$ 4.38						Cr$ .49
12	Cr$	Cr$ 1.91	Cr$ 8.29					Cr$ .45

Summary of the quota system

In the four models described, the quota system policy works to reduce the sugarcane output of the optimal efficiency allocation attained by the standard allocation model generally. This reduction procedure in the output of sugarcane also works to spread out the sugarcane activities rather than concentrate them for specific profitable production activities of sugarcane. Naturally, this process reduces the total area of the sugarcane to the relation of the restriction of the sugarcane.

The quota system policy reduces the quantity of the sugarcane output as well as the quantity of the absolute quantity of the sugarcane area through all four models. This process is passed to search for the second alternative profitable production activities, i.e., the crop activities in the dynamic linear programming framework. This induces the reduction of the net income because, implicity, the sugarcane activities are the most profitable. Further the input level of each activity is different, especially between the sugarcane activities and the crop activities. This is reflected in the quantity of the input factor requirement level. These results are shown in the four models in comparison with the standard solution.

From all input resources labor is given special consideration. The impact of hired labor under the quota system works to reduce this inpact level over all four models in general, excluding Model II. This happens because the crop activities substituted for the sugarcane production activities are, in general, for the cotton activity, less labor consuming and this is the fundamental reason for the impact on the hired labor requirement by the quota system. However, as we have seen in Model II, if the level of the activity of cotton is increased sufficiently by the reduction of the level of the sugarcane activity, then, since the cotton activity is a greater labor-consuming activity than sugarcane, the result of the level of the hired labor requirement appears at the increased levels as seen in Tables 55 and 85.

Except in the case of Model II, the reduction of the sugarcane land level and the hired labor level works naturally in reducing the scarcity of these resources. This is shown by the reduction of the shadow price level of these resources. However, since the substituted alternative crop production activities are rather high capital-consuming processes, the shadow prices of capital in the quota system are generally increased. In the example of capital, Model II is not an exception to this.

Often, the reduction of the sugarcane activity level forces the net income to a low level because the sugarcane activities are the most profitable considered. Therefore, the net income is reduced greatly by the quota system policy. However, this policy achieves a more stable net income distribution over all 12 years than does the standard efficiency production allocation. This stabilization occurs regardless of the reduction of the total net income because the distribution of net income is spread over many alternative production activities, including both sugarcane and crop production.

Model III and Model V are not presented in this chapter because these two models belong to the highest class VIII, which produces more than 10,000 tons of sugarcane per year. The I. A. A. official agency of the sugarcane industry, made the classification of the quota favorable for the larger farmers using the quota system as assumed in the sampling classification. This system thus creates serious problems on income distribution in the Brazilian society. These kinds of problems will be studied in the near future along with studies of the other industries of the agricultural sector.

Aggregation

This section presents a rough aggregation of the results of the standard calculation and of the quota system calculation, following the model of aggregation presented in the chapter describing the model. This aggregation will be made only by multiplying the total number of the farms of region I by the results of the calculation of each representative farm of each tractor type. The results are added to find the estimate for the region. The calculation was executed for the net income, the total production of sugarcane and the total requirement of hired labor.

Standard models

The calculation of tractor type I was made by multiplying the number of farms 677 by the columns of the net income, of the output of the sugarcane and of the hired labor. These results are shown in Table 98.

The objective function value multiplied by the 677 farms is Cr $62,165,897.35 for this model.

The total output and the hired labor days are 11,765,583 tons and 9,174,704 days respectively.

The result of the standard model of tractor type II is multiplied by the number of 1,112 farms. The aggregation results are shown in Table 99. The net income, the sugarcane output and the total hired labor days are Cr $294,454,964.56, 46,359,280 tons and 15,806,520 days respectively.

The tractor type III and the tractor type V are shown in Tables 100 and 102. These two models are exactly the same as the result of the quota system within the definition of the quota system as explained previously.

The tractor type III has the net income, the sugarcane output and the hired labor days of Cr $179,121,847.68, 24,593,520 tons and 4,983,936 days.

The tractor type V has the net income, the sugarcane output and the hired labor days of Cr $792,609,265.80, 103,887,696 tons and 21,798,634 days respectively.

Table 98. Aggregation of the tractor type I Model--677 farms

Year	Net income /Cr$	Output of sugarcane/ton	Total hired labor/day
1	-13,892,182.17		908,534
2	9,422,384.45	1,519.865	1,286.977
3	5,515,417.45	1,215,892	435,311
4	14,214,508.64	1,687,084	605,238
5	2,276,338.03	407,554	856,405
6	-9,830,859.17	735,899	795,475
7	13,145,329.31	2,125,103	1,182,719
8	11,855,461.52	1,487,369	616,070
9	4,478,876.29	931,552	243,720
10	7,827,920.82	689,863	982,327
11	7,748,088.98	551,755	731,837
12	8,798,359.70	413,647	530,091
Total		11,765,583	9,174,704
Objective function	62,165,897.35		

Table 99. Aggregation of the tractor type II Model--1,112 farms

Year	Net income /Cr$	Output of sugarcane/ton	Total hired labor/day
1	-66,503,682.64		1,073,080
2	26,168,284.56	5,660,080	2,518,680
3	37,214,859.20	5,299,792	1,698,024
4	15,379,771.76	3,299,304	392,536
5	7,351,532.08	2,702,160	811,760
6	28,456,057.36	5,035,136	2,142,824
7	46,975,572.64	5,174,136	1,622,408
8	27,560,052,64	3,300,416	392,536
9	5,589,566.32	2,703,272	811,760
10	42,144,830.96	5,035,136	2,142,824
11	63,908,886.24	5,174,136	1,516,768
12	68,421,137.60	2,975,712	678,320
Total		46,359,280	15,801,520
Objective function	294,454,964.56		

Table 100. Aggregation of the tractor type III Model--48 farms

Year	Net income /Cr$	Output of sugarcane/ton	Total hired labor/day
1	-19,580,873.60		69,312
2	27,836,480.64	3,113,520	811,824
3	28,594,237.92	2,924,832	724,128
4	12,831,016.80	1,755,744	218,448
5	-963,857.28	1,064,928	
6	17,197,549.92	2,472,048	532,416
7	27,728,807.52	2,862,960	698,208
8	14,415,079.68	1,847,232	277,920
9	-1,597,046.88	1,243,200	
10	17,524,501.44	2,495,808	542,928
11	27,766,191.84	2,886,768	708,528
12	24,710,695.20	1,926,480	400,224
Total		24,593,520	4,983,936
Objective function	179,121,847.68		

Table 101. Aggregation of the tractor type IV Model--193 farms

Year	Net income /Cr$	Output of sugarcane/ton	Total hired labor/day
1	-10,051,347.36		418,617
2	6,243,050,13	965,579	636,321
3	2,057,376.14	656,586	157,681
4	5,714,878.61	924,663	325,398
5	2,458,179.24	364,577	488,097
6	-2,565,429.34	414,371	375,771
7	6,351,485.25	892,239	467,253
8	3,860,899.38	533,838	322,889
9	-1,729,119.81	426,723	191,263
10	4,866,080.05	671,061	583,439
11	4,725,367.61	533,452	339,487
12	5,177,116.92	363,419	186,052
Total		6,746,508	4,491,882
Objective function	40,673,327.59		

Table 102. Aggregation of the tractor type V Model 242 farms

Year	Net income /Cr$	Output of sugarcane/ton	Total hired labor/day
1	-60,484,901.62		1,319,384
2	65,846,017.16	8,268,414	1,667,622
3	61,725,504.94	8,599,954	1,710,940
4	67,929,579.08	10,417,616	1,882,276
5	63,289,258.12	9,541,576	1,703,922
6	63,025,110.28	9,382,582	1,705,132
7	63,853,568.24	9,557,306	1,735,140
8	41,082,295.10	9,554,644	1,417,152
9	79,595,474.64	11,527,428	2,332,880
10	71,807,774.28	10,819,336	2,065,470
11	102,421,524.48	10,230,308	2,294,886
12	94,415,552.22	5,988,532	1,963,830
Total		103,887,696	21,798,634
Objective function	792,609,265.80		

Table 103. Aggregation of the tractor type VI Model--145 farms

Year	Net income /Cr$	Output of sugarcane/ton	Total hired labor/day
1	-9,295,098.85		101,355
2	6,959,546.15	952,505	231,275
3	8,089,915.40	936,845	222,720
4	2,183,528.90	529,395	46,545
5	-1,550,869.25	419,195	
6	6,164,936.00	892,910	204,885
7	7,289,057.20	877,395	196,910
8	2,183,528.90	529,395	46,545
9	-1,550,869.25	419,195	
10	6,164,936.00	892,910	204,885
11	7,289,057.20	877,395	196,910
12	6,118,752.05	529,395	96,135
Total		7,856,535	1,548,165
Objective function	40,849,360.85		

Crop activities

In this model, two crop enterprise, rice and cotton, are entered into the solution. The rice enterprise enters into the solution in the first year at the level of 22.50 alqueires, which corresponds to 11% of the total arable land. In the 5th, 8th and 12th years the cotton enterprise is entered into the solution at the level of 63.56 alqueires, 16.51 alqueires and 90.00 alqueires which corresponds to 14%, 4% and 20% of the total arable land respectively.

These production levels are shown in Table 59. In this model the crop production activities are used only to complement the technical deficiencies of the sugarcane production activity.

Hired labor activities

The size of farm of this model is much greater than the two previous models discussed. This means that this farm keeps many fixed laborers available throughout the year in sufficient quantity for the planting and weed treatment periods. This is shown in the column of labor for November to April where, except for the first year, all 12 years appear at the quantity of zero. In the first year, 1,444 hired labor days are needed, an equivalent of around 10 persons during the planting and weed treatment period, but the harvesting labor level is zero.

Table 104. Quota system--aggregation of the tractor type I Model--677 farms

Year	Net income /Cr$	Output of sugarcane/ton	Total hired labor/day
1	-7,898,531.92		161,126
2	2,902,197.45	677,000	151,648
3	5,137,048.92	677,000	68,377
4	1,720,947.54	677,000	171,958
5	3,480,037.26	677,000	296,526
6	3,600,766.67	677,000	122,537
7	2,768,686.28	677,000	165,865
8	2,875,252.85	677,000	100,351
9	3,998,558.33	677,000	308,712
10	2,368,917.78	677,000	121,860
11	3,819,579.84	677,000	285,017
12	9,575,948.36	677,000	145,555
Total		7,447,000	2,111,563
Objective function	34,411,449.64		

Table 105. Quota system--aggregation of the tractor type II Model--1,112 farms

Year	Net income /Cr$	Output of sugarcane/ton	Total hired labor/day
1	-32,620,030.72		1,883,728
2	15,471,567.36	3,336,000	2,222,888
3	6,078,681.28	3,336,000	1,112,000
4	16,800,529.68	3,336,000	1,718,040
5	11,020,842.96	2,827,816	1,457,832
6	-1,103,782.32	2,661,016	998,596
7	36,305,169.44	3,336,000	1,984,920
8	9,184,441.68	2,225,112	1,432,256
9	-6,733,593.68	2,232,896	807,312
10	15,513,578.72	3,336,000	2,043,856
11	22,529,620.40	3,269,280	1,813,672
12	27,267,485.44	2,225,112	983,008
Total		32,121,232	18,446,968
Objective function	108,611,731.04		

Table 106. Quota system--aggregation of the tractor type IV Model--193 farms

Year	Net income /Cr$	Output of sugarcane/ton	Total hired labor/day
1	-6,758,450.84		
2	-65,778.26	386,000	22,967
3	1,964,641.57	386,000	26,248
4	243,515.82	386,000	73,919
5	1,113,637.02	386,000	34,933
6	690,710.33	386,000	28,950
7	1,002,696.76	386,000	40,337
8	948,139.52	386,000	14,282
9	892,841.16	386,000	60,023
10	1,013,688.11	386,000	31,266
11	1,132,026.06	386,000	26,441
12	4,677,082.87	386,000	58,479
Total		4,246,000	487,325
Objective function	20,292,213.00		

Table 107. Quota system--aggregation of the tractor type VI Model--145 farms

Year	Net income /Cr$	Output of sugarcane/ton	Total hired labor/day
1	-4,226,594.85		
2	1,734,249.30	290,000	
3	2,010,343.80	290,000	
4	992,068.25	290,000	
5	2,032,573.75	290,000	
6	1,855,050.25	290,000	
7	1,484,537.55	290,000	
8	1,896,530.40	290,000	
9	1,563,449.45	290,000	
10	1,414,537.35	290,000	
11	2,432,583.80	290,000	
12	3,714,981.20	290,000	7,540
Total		3,190,000	7,540
Objective function	16,904,159.45		

respectively. Again, as shown in Table 107, the reduction in this model of the hired labor requirement is tremendous.

Comparison between the results of the standard optimization and of the quota system

In this section the two results of the aggregation are presented in summary form in Tables 108 and 109.

The net income of this region I is reduced to Cr $1,151,950,666.61 from Cr $1,409,874,663.83, which is the result of the standard calculation. The difference is Cr $257,923,997.22, due to the quota system policy. Further, the impact of this policy on the output of the sugarcane and the hired labor is highly significant. The output of the sugarcane is reduced to 175,485,448 tons from 201,209,122 tons, a difference of 25,723,674 tons. Also, the hired labor is reduced to 47,835,966 days from 57,798,841 days; the difference is 9,962,875 days which has a very significant impact.

Further, the comparison between the actual production of sugarcane in 1968, which was 14,697,057 tons, and the programmed efficiency allocation, which is 16,767,427 tons, was obtained by dividing 201,209,122 tons by 12 years. The difference is more than 2,000,000 tons per year in the whole State of Sao Paulo. Further, the total output of the sugarcane of the quota system per year divided by 12 is 14,623,787 tons. The quantity is almost equivalent to the real production of the whole State of Sao Paulo in 1968 which was 14,697,057 tons.

Table 108. Aggregation of the standard optimization for each tractor type model

Model	Net income /Cr$	Output of sugarcane/ton	Total hired labor/day
Tractor type I	62,165,897.35	11,765,583	9,174,704
Tractor type II	294,454,964.56	46,359,280	15,801,520
Tractor type III	179,121,847.68	24,593,520	4,983,936
Tractor type IV	40,673,327.59	6,746,508	4,491,882
Tractor type V	792,609,265.80	103,887,696	21,798,634
Tractor type VI	40,849,360.85	7,856,535	1,548,165
Total	1,409,874,663.83	201,209,122	57,798,841

Table 109. Aggregation of the quota system for each tractor type model

Model	Net income /Cr$	Output of sugarcane/ton	Total hired labor/day
Tractor type I	34,411,449.54	7,447,000	2,111,563
Tractor type II	108,611,731.04	32,121,232	18,446,968
Tractor type III	179,121,847.68	24,593,520	4,983,936
Tractor type IV	20,292,213.00	4,246,000	487,325
Tractor type V	792,609,265.80	103,887,696	21,798,634
Tractor type VI	16,904,159.45	3,190,000	7,540
Total	1,151,950,666.61	175,485,448	47,835,966

This is an amazing difference. It happens in the State of Sao Paulo because there is no good orientation for farm management through the extension services. This is the weakest point in the State Government. However, in the near future these problems, it is hoped, will be solved step-by-step.

CHAPTER VI. SUMMARY AND CONCLUSIONS

This section presents an overall summary and some specific conclusions which include policy recommendations, limitations, and suggestions for future studies. The conclusions are primarily based on the objectives presented in the objectives section of this study.

Observing the history of man's economic development over 100 years or 1,000 years or even more, researchers have noted the accumulation of knowledge and the organization of its use in human life. If the accumulation of knowledge is defined as technology, we can say it has increased the production of necessities for man, and that it has developed from an exceedingly simple form to today's complicated one. This is seen in world history in which we have moved from an extractive mode of living to the highly industrialized societies of today.

If, for convenience, we divide society into two sectors, the industrial and the agricultural, we see over time a pattern of economic development that reveals a shrinkage of the agricultural sector and an expansion of the industrial sector in the sense of the numbers of population employed by each. I have noted this development in three examples: the United States of America, Japan and Brazil. The general pattern is that the number of people who work in the agricultural sector are decreased by an increase in productivity per person and thus, these workers are released for other sectors. This is the standard pattern of economic development in the agriculture of developed nations.

In the long run, the above statement is certainly true. In the short run, however, if we define a 5-year period only this pattern of economic development may not work. An example of this is observed in the Brazilian case. A pattern breakdown occurs because of the many complexities between the agricultural sector and the other sectors, especially in the demand and supply structure. Sometimes, therefore, technological changes in the short run cannot be expected.

In Brazil, especially in the State of Sao Paulo, this incompatible problem happens against the long run pattern of economic development. The problem is the overflow of the population from the rural areas to the urban areas. Even though the Brazilian economy is moving fast--more than 10% rate of growth in these 5 years--the nonagricultural sector cannot sufficiently absorb those people who come from the rural area. The present study focuses on this matter, using the most convenient data available: sugarcane production in the State of Sao Paulo. The present study was planned to see whether the policy of the government was correct for solving the problem of the Brazilian society in the short run sense. The question studied was whether the quota system policy helps economic development or not.

The normative technique of dynamic linear programming, suitable to sugarcane production, was used to make the study.

To develop the regional aggregation, six models were developed in the present study, based upon the tractor types. These six models were calculated two times: as the standard model, normal optimization procedure and as the quota system model using the restriction on the sugarcane production according to the I.A.A. (Institute of Sugar and of Alcohol).

Unfortunately, the present study had neither sufficient time nor budget to present the demand forhired labor and the supply of sugarcane that have been computed through MPSX routine. However, these results will be presented in the future.

For all six models, optimization is achieved as seen in the results. Further, optimization of the quota system policy is also achieved, with results shown in the results of the quota system policy.

Through these calculations and analyses, the findings are that:

1. the quota system policy reduces the output of the sugarcane;
2. the quota system policy reduces the net income of this region drastically, since the alternative crops suitable for substitution are not as profitable as is sugarcane in ceteris paribus;
3. the quota system policy has reduced the absorption of the hired labor in this specific region of the State of Sao Paulo.

These results show that the quota system procedure, the product of the great depression of 1929 in the world market, works against the present economic phenomena of the State of Sao Paulo. On the one hand, the state government is faced with overcrowded urban populations. On the otherhand, it is faced also with the necessity of producing sufficient food to feed these people, as well as being faced with pressures from the international food market which needs more food at cheaper prices. Recently the Brazilian government arrived at a trade agreement with Red China and the U.S.S.R., this agreement with the U.S.S.R. and Red China contracting to sell Brazilian sugar to these nations at the cost of $80 million and $30 million, respectively.

Under these circumstances, the Brazilian government should work to remove the old regulation of the quota system and to institute the efficient allocation of scarce resources in the sense of the standard optimization allocation described in the present study.

In the short run, in the sugarcane industry, the government should abolish the quota system and orient the sugarcane industry to make use of efficient allocation of the scarce resources, considering equitable distribution of the constraints of these resources. In the long run, the government must try to orient the state or the nation to move toward a pattern of economic development, considering the technological changes in the agricultural and nonagricultural sectors.

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APPENDIX A. DERIVATION OF SAMPLING FORMULA

If we define critical rate d and decide confidence level 1 - d, then the confidence coefficient is decided. Letting our objective of the coefficient of variation be

(1) $$T_{\bar{x}}/\bar{X}$$

where $T_{\bar{x}}$ = standard derivation of sample mean

$\bar{X}$ = population mean,

if we accept error level until ε, then the total sample of the proportional sampling procedure is

(2) $$\bar{z}\,(T_{\bar{X}}/\bar{X})^2 \leq \varepsilon^2$$

where z = confidence coefficient. However, by derivation of $T^2_{\bar{x}}$, which is

(4)[1] $$T^2_{\bar{x}} = \frac{1}{N^2}\left(\frac{N}{n} - 1\right) \sum_{j=1}^{R} N_j T_j^2$$

Equation 2 is substituted for Equation 4 if all coefficients are arranged as the following, we get the result of the final equation which determines the number of the sample:

(5) $$n \geq \frac{N \Sigma N_j T_j^2}{(N\varepsilon\bar{X}/z)^2 + \Sigma N_j T_j^2}$$

---

[1]The derivation of Equation 4 is seen in Neguishi (30).

APPENDIX B. INPUT PRICES

Adubos--Praca de Piracicaba

1.	Aldrin 5%	NCR$ 1,60 kg
2.	Nitrosin liquido	NCR$ 14,00 litro
3.	Nitrosin em po	NCR$ 2,00 kg
4.	Nitrosin granulado	NCR$ 3,00 kg
5.	Shell liquido	NCR$ 14,40 litro
6.	Shell em po	NCR$ 2,00 kg
7.	Hebirex po	NCR$ 2,00 kg
8.	Hebirex liquido	NCR$ 12,00 litro
9.	Jupiter	NCR$ 1,83 litro
10.	Blenco po	NCR$ 2,00 kg
11.	Quimbrasil	NCR$ 1,90 kg
12.	Dow	NCR$ 4,50 lata
13.	Mudas	NCR$ 17,80 tonelada
14.	33	NCR$ 2,00
15.	Brasil em po	NCR$ 1,90
16.	4 paus	NCR$ 4,50 litro
17.	Mirex	NCR$ 6,00 kg
18.	Formecida dimagro	NCR$ 2,00 kg
19.	Jupiter	NCR$ 1,50 garrafa

Inseticidas e Fungicidas

1.	Manzante	NCR$ 92,00 kg
2.	Rhodiatox 1,5% Parathion	NCR$ 0,45 kg

Herbicida

1.	Dow pon	NCR$ 15,00 kg

A N O - 1 969

Equipamento	Preco Unitario	Duracao
Arado Animal	26,00	0,2
Bico de Pato	6,00	0,166
Boi de Tracao	397,89	0,2
Burro	304,90	0,067
Carrinho	500,00	0,1
Carpideira	60,00	0,166
Carroca	600,00	0,1
Carrocao	700,00	0,1
Cavalo (egua)	275,00	0,1
Cultivador Adub. Animal	200,00	0,125
Grade (15) dentes	85,00	0,1
Grade (13) dentes	72,00	0,1
Grade (10) dentes	35,00	0,1
Polvilhadeira	110,25	0,2
Plantadeira (Manual)	8,90	0,2
Pulverizador	179,00	0,2
Planet	54,00	0,166
Riscador	200,00	0,1
Semeadeira	166,88	0,1
Sulcador Animal	200,00	0,1
Charrete	550,00	0,1