A normative sugarcane supply function and optimum land rental plan for a proposed expansion of the Sragi sugar factory in central Java, Indonesia
by Rudolf Solindungan Sinaga

A thesis submitted in partial fulfillment of the requirements for the degree of DOCTOR OF PHILOSOPHY in Applied Economics
Montana State University

Abstract:
The Indonesian Agro-Economic Survey was appointed to carry out a survey on the availability of sugarcane supply for the factory to process in each individual working area of the factories proposed by the International Development Association for rehabilitation in Java, Indonesia.

The author took some of the data collected in the survey with him to Montana State University in support of this dissertation.

The main objectives of this study are: (1) to derive a normative land-rent supply schedule faced by the Sragi factory in its working area, and (2) to derive a normative sugarcane supply function and to determine an optimum land-rental plan for the Sragi sugar factory.

The technique of variable price linear programming is employed to generate the relationship between the minimum rental prices paid by the sugar factory and the corresponding maximum amounts of land the farmers would be willing to rent to the sugar factory. The technique of variable resource programming is employed to generate the relationship of various levels of sugarcane produced in the field and their associated marginal and average total costs of producing sugarcane in the field, and the optimum land-rental plan for the Sragi factory for various levels of sugarcane production.

The land-rental supply schedule generated from the solution to the first linear programming model suggests that on the average, the land-rent rate paid by,the factory should be at least twice the land rent paid in the 1972/73 crop season.

The solutions to the second linear programming model suggest that the Sragi sugar factory does not have to expand its current working area to get enough land to grow sugarcane to meet its cane needs for producing up to 70,000 tons of refined sugar.

The total cost of producing sugar at the factory door for the 1972/73 crop season is approximately Rp 65.5/Kg. Under the proposed rental plan total cost could increase to Rp 69.8/Kg., and 22.3 percent or about Rp 15.6/Kg., would be attributed to the cost of renting land from farmers.

If it were the goal to hold down the price of sugar at the factory door, then farming costs to the mill, factory costs, and other mill costs such as management costs could be reduced and the proposed rents could be paid. If these costs could not be reduced, the government could increase the wholesale price of sugar. Either alternative would probably be more desirable than coercing the farmers into accepting rental payments that are less than their opportunity costs.

A NORMATIVE SUGARCANE SUPPLY FUNCTION AND OPTIMUM LAND RENTAL PLAN FOR A PROPOSED EXPANSION OF THE SRAGI SUGAR FACTORY IN CENTRAL JAVA, INDONESIA

by

RUDOLF SOLINDUNGAN SINAGA

A thesis submitted in partial fulfillment
of the requirements for the degree

of

DOCTOR OF PHILOSOPHY

in

Applied Economics

Approved:

Edward P. Ward
Chairman, Examining Committee

L. J. McConnen
Head, Major Department

Henry L. Parsons
Graduate Dean

MONTANA STATE UNIVERSITY
Bozeman, Montana

January, 1975

ACKNOWLEDGMENTS

I am indebted to Dr. Edward H. Ward, my major professor, who encouraged me at all times and gave me indispensable advice throughout my course work and thesis preparation at Montana State University.

From the preparation of a research proposal to the writing of the draft of the first three chapters of this thesis, I have worked mainly under the supervision of Drs. R. O. Wheeler and E. H. Ward. I am grateful to Dr. Wheeler, who once acted as the most active member of my thesis committee, but who took a new job before the completion of the thesis. Since then, I have been working mainly under Dr. R. J. McConnen and Dr. E. H. Ward. I am indebted to Dr. McConnen, who, regardless of his tight daily schedule, could still manage to share his time with me. Without Dr. McConnen's involvement and motivation, my thesis would not have been finished this time.

Thanks are also due to Drs. M. E. Quenemoen, O. R. Burt, F. McFeely, and D. Boyd, who served on the graduate committee.

During the period of my studies, I have been on leave of absence from Bogor Agricultural University, Bogor, Indonesia. I am grateful for their continuous interest in and assistance to me.

I would like to express my sincere appreciation to the Agricultural Development Council, Inc., New York, for their generous support throughout the course work of my Ph.D. program and for returning me to Indonesia for six months for collection of data in support of this thesis.

I gratefully acknowledge the cooperation of the Sragi Sugarcane Factory personnel, Mr. Soeroyo, the administrator and his crop managers, Mr. Margono and Mr. A. S. H. Simatupang.

I also thank Dr. A. T. Birowo, Executive Director of the Agro-Economic Survey, who visited me at Montana State University to invite and encourage me to write a thesis on the sugarcane problem.

Of Professor Dr. Bachtiar Rifai, I should say that he deserves to have his dream fulfilled that all his former assistants at Bogor Agricultural University would have their Ph.D.'s some day.

Drs. Sayogjo and David H. Panny were my first teachers in research methodology on Indonesian rural economy. I thank them both.

It is a pleasure to thank Mr. Harlen Hames and Mr. Stuart Townsend for their computer programming assistance, and Peggy Humphrey, who faithfully typed my manuscript.

Special thanks go to my father-in-law, Mr. Ph. Hutabarat, for his continuous moral support to me and my family. Without his encouragement, I would not have decided to work on this Ph.D.

Finally, I express well-deserved appreciation and gratitude to my wife, Saida, and my two children, Iman and Angela, whose patience, encouragement, and understanding have certainly contributed to the completion of my course work and this research.

TABLE OF CONTENTS

TABLE OF CONTENTS (cont'd.)

TABLE OF CONTENTS (cont'd.)

LIST OF TABLES

LIST OF TABLES (cont'd.)

LIST OF FIGURES

ABSTRACT

The Indonesian Agro-Economic Survey was appointed to carry out a survey on the availability of sugarcane supply for the factory to process in each individual working area of the factories proposed by the International Development Association for rehabilitation in Java, Indonesia. The author took some of the data collected in the survey with him to Montana State University in support of this dissertation.

The main objectives of this study are: (1) to derive a normative land-rent supply schedule faced by the Sragi factory in its working area, and (2) to derive a normative sugarcane supply function and to determine an optimum land-rental plan for the Sragi sugar factory.

The technique of variable price linear programming is employed to generate the relationship between the minimum rental prices paid by the sugar factory and the corresponding maximum amounts of land the farmers would be willing to rent to the sugar factory. The technique of variable resource programming is employed to generate the relationship of various levels of sugarcane produced in the field and their associated marginal and average total costs of producing sugarcane in the field, and the optimum land-rental plan for the Sragi factory for various levels of sugarcane production.

The land-rental supply schedule generated from the solution to the first linear programming model suggests that on the average, the land-rent rate paid by the factory should be at least twice the land rent paid in the 1972/73 crop season.

The solutions to the second linear programming model suggest that the Sragi sugar factory does not have to expand its current working area to get enough land to grow sugarcane to meet its cane needs for producing up to 70,000 tons of refined sugar.

The total cost of producing sugar at the factory door for the 1972/73 crop season is approximately Rp 65.5/Kg. Under the proposed rental plan total cost could increase to Rp 69.8/Kg., and 22.3 percent or about Rp 15.6/Kg., would be attributed to the cost of renting land from farmers. If it were the goal to hold down the price of sugar at the factory door, then farming costs to the mill, factory costs, and other mill costs such as management costs could be reduced and the proposed rents could be paid. If these costs could not be reduced, the government could increase the wholesale price of sugar. Either alternative would probably be more desirable than coercing the farmers into accepting rental payments that are less than their opportunity costs.

CHAPTER I

INTRODUCTION

In January, 1971, at the request of the Government of Indonesia, the United Nations Development Program (UNDR) commissioned the Indonesian Sugar Study (ISS) to formulate a 10-year program to meet domestic sugar demand, at the least cost to the economy, and prepare a project to increase sugar production for international financing. The study was carried out by a British consortium; Bookers Agricultural and Technical Services, and Tate and Lyle Technical Services in association with the Economist Intelligence Unit. Based on the consortium study, ISS prepared an initial three-year project which proposed construction of two new sugar factories, major expansion of one, and rehabilitation of twelve other sugar factories, with ancillary transportation and agricultural facilities [1,p.1].

In October-November, 1972, an International Development Association (IDA) appraisal mission to Indonesia conducted a further study. Based on the findings of the appraisal mission and on data from ISS, the IDA has established that the construction of new factories would be too expensive and could not be justified at that time. Major rehabilitation of three factories and minor rehabilitation of twelve is recommended by IDA instead. This rehabilitation project will increase the sugar supply substantially and at a lower cost than would be the case if new factories were constructed [1,pp.1-2].

Major rehabilitation was proposed for the Sragi, Gempolkrep, and Pesantren sugar factories [1,Annex 5,p.1]. Sugar factories that belong to the minor rehabilitation project are Jatiwangi, Tersana Baru, Gempol, Bandjaratma, Sumberharjo, Cepiring, Rendeng, Ceper Baru, Mojosragen, Tasikmadu, Lestari, and Cukir [1,Annex 6,p.1]. 1/ The project would markedly increase the milling capacity of the factories ranging from 70 percent for minor rehabilitation to 200 percent for major rehabilitation above their current capacities [1,p.8].

IDA is aware that adequacy of cane supply to meet forecast capacity is critical and depends on many factors such as the value of alternative crops, irrigation availability, and farmers' attitudes [1,p.8]. 2/ Therefore, the IDA recommended in their report that before any rehabilitation is planned, a survey must be carried out to make quite sure that sufficient land would be made available for cane production [1,p.21]. The resulting Draft of Terms of Reference for Cane Supply Survey proposed by IDA is presented in Appendix I [1,Annex 7].

In 1973, the Indonesian Sugar Project on behalf of the Director General of Estates of the Ministry of Agriculture appointed the Indonesian Agro-Economic Survey (AES) to carry out a survey on the

---

1/ Underlining indicates these factories are of first priority in the minor rehabilitation project.

2/ Sugarcane or cane refers to sugarcane crop as the raw material for the factory to process. Cane sugar or sugar refers to centrifugal or refined sugar as the final product.

availability of sugarcane supply for factory processing in each of the individual sugar factory working areas belonging to the rehabilitation project. 3/

The objectives of the survey carried out by AES are to determine in each factory working area: [39,p.3]

a) The total area of the factory concession.

b) The area currently in cane grown by the factory and estimated yields.

c) The area currently in cane grown by the farmers and estimated yields.

d) The area available for expansion by the factory within the concession area, divided into area available for planting and area available for factory ratoon, along with estimated yields. 4/

e) The area available for ratooning by farmers within the concession regardless of the factory's capacity and estimated yields.

f) The rents proposed and present prices for sugar and other crops:

3/ The Agro-Economic Survey was created in 1965 as an ad hoc inter-ministerial research organization. The Minister of Agriculture is the Chairman of the Policy Board composed of approximately one dozen members including policy makers in the Ministry of Agriculture, Public Works, Land Settlement and Cooperatives, Home Affairs, Ministry of Trade, Central Bank, and Food Supply Authority [2,pp.7-9]. Dr. A. T. Birowo is the current Executive Director of the organization.

4/ Ratoon is the regrowth of sugarcane from the stubble of the previous crop.

1) What area farmers would be willing to lease along with estimated yields.

2) What total area farmers would be willing to ratoon, the number of years that ratooning is desired, and estimated yields.

For the first round of the survey, AES conducted a survey in the working area for all three factories of the major project--Sragi, Gempolkrep, and Pesantren--in December-January, 1974. The author was appointed by the Executive Director of AES to supervise the survey on the preparation of the survey, collecting and editing the data, and tabulating the data for further analysis. In April, 1974, the author took some of the data with him to Montana State University to support this thesis. The AES team will do separate data analysis and report writing in Indonesia. The thesis will complement the AES report.

This thesis, after review of general nature of the information collected from each factory, will only present the specific data for the Sragi sugar factory and its working area. 5/ The thesis is therefore a case study of the Sragi factory, but this case study is used as a means of addressing the more general problems involved. The specific objectives of the study in this thesis are:

1) To calculate the economic opportunity cost for the farmers to rent their land to the Sragi factory, and to derive a normative

---

5/ For simplicity the Sragi sugarcane factory will be referred to as Sragi factory or factory in this thesis.

land-rent supply schedule faced by the Sragi factory in its working area; and

2) To derive a normative sugarcane supply function, and to determine an optimum land rental plan for the Sragi factory.

CHAPTER II

INDONESIAN SUGARCANE INDUSTRY

Production and Consumption of Sugar in Indonesia

The sugar industry was one of the most important industries in Indonesia for many years before World War II. In 1928, there were 178 sugar factories operating in Java, harvesting about 200,000 hectares of cane and producing nearly 3 million tons of sugar, almost half of which was exported. At this time, Java was the second largest supplier of sugar in the world market, surpassed only by Cuba [3,p.1].

Indonesian sugar production had already been curtailed before World War II because of the depression and world over-production. The Indonesian sugar industry operations were then severely interrupted by the Japanese invasion and by the postwar Indonesian struggle for independence. Production revived after the war but never again approached the prewar peak.

In recent years, the output of the sugar factories has been something over 700,000 tons per annum produced by 55 factories. However, since 1966 consumption of sugar in Indonesia has overtaken domestic production and instead of a surplus for export as previously, imports of about 100,000 tons per annum have been required to meet domestic demand. Table II-1 indicates the pattern of production, exports,

TABLE II-1. WHITE SUGAR PRODUCTION, EXPORTS, IMPORTS, AND APPARENT CONSUMPTION, 1952-1972.*

1	2	3	4	5
Year	Production	Exports	Imports	Apparent Consumption 1/
		Tons		
1952	460,264	1,181	--	395,092
1953	619,829	97,369	--	498,928
1954	717,712	212,200	--	499,851
1955	852,299	199,543	54	642,746
1956	785,723	174,772	--	612,842
1957	828,451	142,864	92	665,870
1958	771,186	87,167	1,695	704,458
1959	855,209	39,000	--	729,993
1960	667,000	34,800	--	707,790
1961	639,000	142,713	--	461,572
1962	583,000	33,279	1,756	591,445
1963	650,284	105,049	70	497,558
1964	647,000	104,627	113	626,018
1965	779,900	75,400	340	672,093
1966	605,000	27,262	23,504	586,063
1967	659,900	--	37,524	739,020
1968	600,595	--	107,757	676,930
1969	732,288	--	77,780	812,298
1970	715,047	--	118,164	833,845
1971	830,000	--	150,000	823,000
1972	889,400	--	90,000	NA

1/ After adjustment for movements in stock levels.

*Source: Bookers Agricultural and Technical Services, Ltd. and Tate and Lyle Technical Services, Ltd. "Indonesian Sugar Study--Final Report." Vol. I (in association with The Economist Intelligence Unit). July, 1972; and Indonesian Food Supply Authority (BULOG).

imports, and consumption of sugar in Indonesia for the last 21 years. 1/

Projections contained in the IDA report indicate that production will increase from 890,000 tons in 1972 to 1,300,000 tons in 1980 including forecasted production from the proposed rehabilitation of the 15 factories. The report also indicates, however, that consumption is expected to double within the same period to approximately 1,600,000 tons. The estimated demand and supply balance of sugar indicates that Indonesia will continue to import sugar until 1980, which on the average, will be about 100,000 tons per year [1,Annex 4,p.3].

General Characteristics of Indonesian and Some Other Countries' Sugarcane Industries

The sugarcane industry in Indonesia has certain characteristics which sharply differentiate it from other sugarcane industries. The differences mainly stem from the unique basis of occupation and use of the land involved in cane production. In other countries, cane is grown either on large estates which are owned and cultivated by the enterprise

---

1/ Figures in Table II-1 only include sugar produced by sugarcane factories as "white sugar" or centrifugal cane sugar. In addition to white sugar produced by the factories there is a substantial production of crude, brown sugar (non-centrifugal sugar) made by a simpler method of processing using smallholders' cane or palms. The production and consumption of all types of non-centrifugal sugar in recent years has been about 350,000 tons per annum which is about one-third of the total sugar production in Indonesia [4,p.43].

owning the factory and devoted to sugar for periods of years without interruption or on smaller, privately owned plots ranging in size from tiny smallholdings to medium-size estates, and also continuous growing and selling of cane for processing to a central factory. In many cases the estates in other countries have been developed for sugarcane on land not previously under systematic cultivation with food crops.

Indonesian Sugarcane Industry

In 1957, following the growing tension between Indonesia and the Dutch over the future status of West Irian, the Dutch-owned sugar factories were expropriated by the Indonesian government and run as government enterprises. Today there are 55 sugarcane factories in Indonesia and all are located on Java Island. Only one of these 55 factories belongs to private shareholders, 48 belong to the government enterprise, and 6 to so-called private companies. Five of this latter group are owned by government agencies (two by Ministry of Finance, two by the Bank of Indonesia, and one by an army group), and one is owned by a local interest [4,p.35].

When sugar production began more than 80 years ago in Java, the most suitable lands for growing cane were already occupied by the Javanese peasants and intensively cultivated with food crops, primarily rice. Sugarcane estates could have been established only at the cost of very serious social disturbance and, at least locally, serious

reduction of food supplies. A system evolved, therefore, by which land was made available for cane cultivation without passing out of the ownership of the local community and without being permanently withdrawn from rice production. Under this system, the land is leased for a single season to a sugar factory and then reverts back to the farm owners of small plots for two seasons. During this time the land is usually planted to rice with some intermediate crops during the dry part of the year if the water supply is insufficient to grow rice continuously. Each factory is allocated a concession area within which it is entitled to arrange leases via this rotation system. Arrangements are worked out with representatives of the village(s) involved by which one-third of the land is scheduled for leasing in each of three successive years. In practice, since sugarcane takes more than 12 months to mature fully plus the fact that some time must be allowed for soil preparation and for clearing after harvest, the length of leasing period is 16 months.

There are at least six technical consequences resulting from the leasing system on the three-year rotation: [4,p.40]

1) This rotational system results in important differences in agricultural practices from other countries. In the other sugarcane producing countries it is normal to ratoon cane for periods of five years or longer, but ratooning cane is not customary in Java. It is therefore necessary to plant cane afresh each year, which involves additional planting costs for labor and planting material from nurseries.

The nurseries occupy about 12 percent of the available land which could otherwise be used to grow sugarcane or other products.

2) Since the lands cultivated with cane are scattered over an area at least three times the area actually planted at any one time, the cane transportation system has to be proportionately more extensive than would be needed for a more compact layout. The cost is consequently increased as well.

3) There are greater administrative tasks and problems. Since the sugar factories have to make leasing arrangements every year, it is time-consuming and a significant burden on the management.

4) Additional costs are involved after harvesting the cane. The cane roots must be removed and the land boundaries must be restored to prepare the land for reversion to rice crops.

5) There are many individual landholdings grouped in such a way as to leave the factory with several fairly small, fairly widely separated areas of cane. This scattering means that agricultural management is complicated, and introducing new cultivation techniques is often difficult.

6) Irrigation and drainage systems cannot be designed and operated to meet the primary requirements of the cane, but are oriented towards rice, which occupies most of the land most of the time.

Sugar production currently is only a small part of total agricultural activities in Indonesia. In 1970, sugarcane occupied only 135,000 hectares. Total cultivated area in Java is about 8 million hectares, and in Indonesia as a whole is over 50 million hectares [1, Annex 2,p.2].

About 85 percent of the total sugar production is marketed and distributed under the government's direct supervision from the government-owned factories. The remainder is independently marketed and distributed by private and quasi-private factories [1,Annex 4,p.3].

The organization of the sugarcane industry in Indonesia is unique. A brief description of the organization of sugarcane industries in Taiwan, the Philippines, and Hawaii is presented to provide a basis for comparison.

Taiwan Sugarcane Industry 2/

Sugar in Taiwan is produced mainly for export, for example, the production in the 1960's was approximately 800,000 metric tons of which nearly 90 percent was for export. The sugarcane industry in Taiwan is controlled by a monopoly corporation called the Taiwan Sugar Corporation (TSC), which is one of the largest government-owned enterprises. Taiwan

---

2/ Information on the Taiwan sugar industry is obtained from the following references: [5,pp.1-8] and [6,pp.24-25].

Sugar Corporation owns 25 well-equipped sugar mills and 188 large-scale farms with a total acreage of about 43,000 hectares. Because sugar in Taiwan is a monopolized industry, those farmers who want to grow cane must contract with the Sugar Corporation in advance. There are no acreage restrictions limiting how much farmers may plant, nor any government compulsion on farmers to plant cane. Contract farmers provide about 70 percent of the total annual supply and the remaining 30 percent is supplied by the mill's farms.

Cane growers under contract can obtain chemical fertilizers and a certain amount of production credit from the Corporation, for which payment may be deferred until after the cane is harvested. The mill is also responsible for helping growers improve the technology of production and cultural practices of growing sugarcane. The growers agree to deliver all of their cane harvest to the mill for the manufacture of sugar and agree to sell a given percentage of their share of refined sugar to the mill for the prevailing purchase price.

Growers receive 55 percent of the refined sugar made from the cane they deliver, and the remaining 45 percent is retained by the mills to cover the processing expenses. Under this contract, however, the farmers are forced to sell at least 65 percent of their share of the refined sugar to the mill for the prevailing purchase price. The mill's purchase price is based on the average export sugar price in the preceding

twelve months. The Corporation controls about 90 percent of the annual sugar production in Taiwan.

In general, the ratoon are regrown from a planting only once, but some farmers ratoon their sugarcane twice or even three or more times in succession. Nearly one-half of the Taiwan cane acreage is propagated by the ratoon method each year. The average size of farm in Taiwan is only about 3 acres (1.21 hectares) and the average size of cane field of these farms is around 0.5 hectare.

Philippine Sugarcane Industry 3/

There are 27 sugarcane factories in the Philippines, all privately owned by independent companies. These factories produced about 1,764,000 short tons per annum in the 1960's.

A unique feature of the Philippine sugar industry is the relationship between the farmers who grow sugarcane and the millers or processors who manufacture the sugar on a share or toll basis. Unlike the situation in other countries where central sugar processing units control sugar production, in the Philippines the farmers have a hand in controlling the production of sugarcane.

The cooperative arrangement between factory owners and farmers in the sugarcane district contained in the milling contract obliges farmers

---

3/ The information was obtained from reference [7,pp.22-35].

to grow sugarcane to be milled while processors agree to transport the cane and to process it into sugar. The sugarcane farmers grant the right-of-way for the railroads of the centrals over their property and agree to plant sugarcane each year on at least one-half of the area of their land during a milling contract period. The processors receive 30 to 40 percent of the sugar produced as compensation for milling and transporting the cane.

The average size of farms is 13.86 hectares, and farms 10 hectares or more and 200 hectares or more are 80 and 43 percent of the total area of sugarcane farms, respectively.

Hawaiian Sugarcane Industry 4/

There are 26 sugarcane factories owned by 23 private companies operating independently of each other, each with its own management. To facilitiate the actual production of sugar, all sugar companies except one are represented by an agency or parent company in Honolulu.

The companies have 238,997 acres devoted to growing sugarcane in Hawaii. More than half the sugar lands are owned by sugar companies. The balance is leased from government or private owners. Irrigated land produces about two-thirds of Hawaii's sugar production. The remaining one-third is produced by unirrigated areas depending solely upon rainfall.

4/ The information was obtained from reference [8,pp.3-7].

Only in Hawaii is the average age of the cane two years at the time of harvest. About one-half of Hawaii's sugar lands are harvested each year. From two or four ratoon crops are obtained from each original planting.

Approximately 97 percent of all Hawaiian raw sugar production is shipped to the United States mainland for refining. About 3 percent is processed in a local refinery, largely for Hawaiian consumption. Total sugarcane production in 1970 was about 1,162,071 short tons of raw sugar.

Land Lease System for Sugarcane

The present land lease system for growing sugarcane in Indonesia must be traced back to the Dutch period when the sugar industry was first introduced. In 1830, a compulsory cultivation system ("cultuur-stelsel") was introduced to the Indonesian peasants, mainly in Java. Under this system of the Dutch colonial government, the farmers were compelled to grow government-owned export crops including sugarcane on one-fifth of their fields, or, alternatively, to work 65 days every year on government-owned estates or other projects as a substitute for the farmers' land taxes [9,pp.52-53]. Hence, the sugar factories, which were all owned by the government obtained land from the farmers without paying for it. In addition, the farmers were also required to work some hours every day in the Dutch estates without pay [10,p.2]. Since sugar-cane demands irrigation and a general environment almost identical to

that of wet rice crops, nearly all the sugarcane was cultivated on the farmers' paddy land.

In 1870, an Agrarian Law was issued to replace the cultivation system. This law was designed to preserve the local population control of the land they owned, and at the same time to encourage the exploitation of the remaining land by non-indigenous enterprises [11,p.129]. The law enabled private corporations to grow commercial crops on leased land for 75 years, and consequently the plantation system flourished rapidly.

Since all sugarcane was owned by the farmers and used for cultivating rice and other food crops, the sugar companies had to obtain land from the farmers to grow sugarcane. For this purpose the Dutch government issued a land lease law in 1918 which was valid on Java and Madura Islands except for Jokjakarta and Surakarta. Big corporations were allowed by law to lease one-third of the farmers' paddy land for 21.5 years, because seven growing cycles for cane and rice equal 21 years. The farmers were allowed to grow food crops on the land after one season had elapsed [10,p.4].

The appropriation of the land by the sugarcane factory was usually regulated under the "glebakan" system; i.e., paddy land in each village within the factory working area was divided into three sectors. These glebakan were released in succession to the sugarcane factory, no matter which individual owned the land within the sector. Under this glebakan system, the land rent was based on a formula which took into account the

opportunity cost to the farmers of releasing their land to the factory. The opportunity cost was computed based on values of two rice crops (one wet-season and one dry-season) and one dry-season cash crop such as corn, soybeans, or peanuts. The value of the land rent paid to the farmers was the calculated opportunity cost minus potential earnings of the farmers working as laborers during the leasing period [11,p.131].

After independence the Indonesian government attempted to provide a more appropriate institutional framework for the sugar industry. New regulations were issued in 1952 to replace the 21.5-year lease agreements with annual or single sugarcane crop agreements. The formula which had been used from 1918 onward to fix the rent locally was then replaced by a procedure in which rent was fixed from year-to-year by the Ministry of Agriculture [11,p.137].

At the present time, the land lease system is only slightly different from the one regulated by the 1910 land lease law. The element of compulsion associated with the renting system in the colonial times has been preserved in order to maintain the level of sugarcane cultivation. For this purpose, a Land Use Law (No. 38 of 1960) was issued to give assurance to the sugar industry that the sugar factories could get enough land to grow sugarcane. 5/

5/ The full text of the Land Use Law No. 38 of 1960 and its official explanations can be found in reference [12,pp.175-188].

Every year the Minister of Home Affairs issues a Letter of Decision or Minister's Regulation. For the 1972/73 sugarcane crop season it contained among others the following decisions: [40]

1) The Form of Payment: The land rent should be paid in the form of money. 6/

2) The Installment: Twice--first when the contract is made, and finally when the farmers hand over their land to the factory. 7/

3) The Amount of Rent: The Minister sets the minimum and maximum amounts of rent for 16-month and 11-month periods. The minimum amount of rent is based on the amount of rent practiced among and by the farmers. The maximum amount is based upon the alternative returns from paddy and second crops, taking into account the financial capacity of the sugar mills to pay the farmers. 8/ For the 1972/73 sugarcane crop season the minimum

---

6/ Since 1967/68 the land rent has been paid in the form of money.

7/ If the factory should decide to return the land to the farmers before the rental agreement termination date, the factory has to pay the full rent. The factory should not pay the first installment earlier than six months before the handing over of the land to the factory. And the first installment should not affect the total land rent received by the farmers (no interest charge).

8/ There is no available information on how the data are gathered to determine the maximum and minimum amounts of rent.

and maximum land rents for 16 months was Rp 60,000 and Rp 80,000, respectively. 9/

4) Delivery Premium: If the farmers deliver the land to the factory in March, April, or May, the factory is supposed to pay a premium. In 1972/73, this premium was Rp 4,800 per hectare for March delivery, Rp 3,200 for April, and Rp 2,400 for May delivery.

5) Late Delivery Premium: If the factory is late in returning the land to the farmers as specified in the contract, the factory must pay the farmers another premium. In 1972/73, this was Rp 4,843.75 per hectare for one month late delivery; Rp 9,687.50 for two months; and Rp 14,531.25 for three months late delivery.

6) Production Premium: For any amount of cane above the 800 quintals (80 tons) produced per hectare, the farmers received Rp 32 per quintal in 1972/73.

7) Clearing Costs: At the end of the season when the land is about to be returned to the farmers there is still a lot of cane stalks, stumps, etc., on the field. The factory is supposed to

---

9/ How much precisely the rent should be for a certain sugar mill is up to the bupati for the area to decide within the minimum and the maximum limits. In the case of Sragi factory for the 1972/73 crop season, the rent for Class II land was Rp 77,500 and for Class III land, Rp 75,500 per hectare for 16 months.

return it in its original clear state, and for this purpose the factory must pay the farmers a land clearing fee. In 1972/73 this was Rp 960 per hectare. 10/

In practice, the local governments do not follow the above regulations faithfully. 11/ The bupati can decide the amount of rent for his area. There is a committee in each kabupaten for calculating the amount of money to be paid per hectare of land as rent and the amount of land to be rented. This committee consists of the bupati personnel from the Agrarian Office, Agricultural Extension Service, Irrigation Office, Farmers' Organization, Courts, Police, etc. 12/ The bupati submits a land rent proposal to the Governor based on this committee's findings and the Governor makes the final decision. For legalizing the bupati's proposal or recommendation, the Governor also convenes a committee with the same membership as that of the kabupaten.

If the process runs smoothly, after the bupati fixes the rent he orders the camats and lurahs (village heads) to find out and determine

---

10/ The rent, all premiums, and the land clearing fee must be paid directly to the farmers in front of and legalized by the village head and camat.

11/ A brief description of the Indonesian Government administrative division of the country is presented in Appendix II.

12/ No information is available on how this committee determines the amount of rent and the amount of land to be rented in each village.

the location of land within the village. The assistant field manager and the village head together determine the location of the land and compile the names of the owners and the size of their holdings. If the land in each village has been divided into three parts (i.e., the glebakan system), one-third of the paddy land is surrendered to the factory for cane each year. 13/ If the glebakan system has been in order, finding the land is a matter of routine work.

After the name and the size of holdings have been fixed and approved by the camat, the contract between the factory and the farmers is then agreed upon and the first installment of the land rent payment is given to the farmers.

Since the local governments permit only a part of the paddy land to be used for cane, fragmentation of the cane growing area is unavoidable. In addition to this, the factory may lease the land for a short period (16 months); i.e., one sugarcane crop growing season. This results in high costs for clearing the land, replanting, and clearing again at the end of the period.

13/ This glebakan system varies from region to region. Even within the factory working area more than one glebakan system can be found. In Sragi factory working area, for example, there are three glebakan systems: 3 years, 4 years, and 5 years of glebakan. The larger the paddy land in a village, the longer the cycle in the village.

Beginning with the 1975/76 crop season, the factories belonging to the rehabiliation project plan to ratoon sugarcane. This means that a new regulation or law should be issued to enable the factories to lease land for more than one crop season.

CHAPTER III

ANALYTICAL MODEL, DATA GENERATION, AND UNIT OF ANALYSIS

Introduction

The purpose of this chapter is to present the basic ideas used in the development of the rest of the thesis. The principal objective of the thesis is to develop a framework for estimating a normative sugarcane supply function and then to use that framework empirically for the Sragi factory working area. Linear programming will be the primary analytical model used.

The first step is to develop a model which will permit the derivation of a normative Land-Rent Response Schedule. The technique of variable price programming is used as a means of estimating the relationship between the rental prices paid by the sugar factory and the corresponding amounts of land the farmers would be willing to rent to the sugar factory. The second step is to develop a model which will be used to generate a normative supply function for sugarcane. The output of the linear programming analysis of step one will be utilized for constructing this second linear programming model. The technique of variable resource programming is used to generate the relationship of various levels of sugarcane output and their associated marginal and average costs. As a by-product of this analysis, an optimum land rental plan is also specified.

Analytical Model

Linear Programming

Linear programming is a widely used tool for empirical analysis of economic problems. It is one of the three types of analytical models used in economics that consist of linear relationships. These three types of analyses are linear programming, input-output analysis, and two-person, zero-sum or elementary game theory. 1/

Multinational groups, individual nations, and even individual firms frequently face normative type problems of determining how factors of production can be best organized. Linear programming is often a useful tool to analyze these problems.

There are three necessary quantitative components of a linear programming problem: linear objective function, resource or other constraints, and alternative methods or activities which affect the objective function and constraints in linear fashion. A problem which has these three components can always be expressed as a linear programming problem.

1/ A brief historical sketch of the development of these three types of analyses can be found in [13,pp.1-5]. Also in the same reference [13,pp.507-512], selected basic works are listed for conveying a reasonably rounded picture of the work which has been done in the three types of analyses up to the late 1950's.

Linear programming problems are set up in terms of matrix algebra. The linear programming maximization problem in general form can be stated as follows: 2/

Maximize CX subject to

$AX \leq B$ and

$X \geq \bar{0}$. 3/

The meaning of the above inequalities will be discussed later in more detail. It may be explained simply as follows.

The first inequality, $AX \leq B$, restricts activities from using more resources than the amounts which are available. For example, the number of hectares of land used for crop production cannot exceed the number of total hectares of land that is available to produce the crops. The second inequality, $X \geq \bar{0}$, prohibits negative values from occurring for any activity. For example, one cannot produce minus 2 hectares of rice crop.

2/ The dual of the maximization problem is a minimization problem. The relationship of these problems is often useful in economic analysis but will not be discussed here. A brief and sufficient economic interpretation of dual problems of a linear programming model can be found in [14,pp.103-121].

3/ The bar sign above 0 refers to zero column vectors.

For purpose of illustration, a simple linear programming problem is used in the following discussion. The example uses the linear programming maximization problem and specific data for a group of farmers in a kecamatan as presented in Table III-1.

Objective Function

The objective function (OBJ) of a profit maximization problem is represented by CX in the above general linear programming problem formulation. This function can also be expressed in equation form as the following:

$$\text{Maximize } CX = c_1x_1 + c_2x_2 + c_3x_3 + c_4x_4 + c_5x_5 + c_6x_6 + 0x_7 + \ldots + 0x_{11}.$$

In matrix notation this is expressed as:

$$\text{Maximize } CX = [c_1, c_2, c_3, c_4, c_5, c_6, 0, 0, 0, 0, 0] \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \\ x_6 \\ x_7 \\ x_8 \\ x_9 \\ x_{10} \\ x_{11} \end{bmatrix}$$

TABLE III-1. DATA FOR LINEAR PROGRAMMING MAXIMIZATION PROBLEM OF A GROUP OF FARMERS IN A KECAMATAN.*

		Real Activities						Disposal Activities					
		(x_1)	(x_2)	(x_3)	(x_4)	(x_5)	(x_6)	(x_7)	(x_8)	(x_9)	(x_{10})	(x_{11})	
	Units	AR_1	ARL	BR_2	BRL	DR_1	DRL	Labor	Cash	ALAND	BLAND	DLAND	Available Resources
	1	2	3	4	5	6	7	8	9	10	11	12	13
OBJ = Return to Land and Family Labor	Rp.	266313	90000	54604	90000	212315	90000	0.0	0.0	0.0	0.0	0.0	
ROWS													
Labor	Man Hrs.	3057	7343	1354	7343	2237	7343	1	0.0	0.0	0.0	0.0	55504800
Cash Capital	Rp.	95467	0.0	34619	0.0	65205	0.0	0.0	1	0.0	0.0	0.0	400000000
Land Type:													
ALAND	Ha.	1	1	0.0	0.0	0.0	0.0	0.0	0.0	1	0.0	0.0	1565
BLAND	Ha.	0.0	0.0	1	1	0.0	0.0	0.0	0.0	0.0	1	0.0	745
DLAND	Ha.	0.0	0.0	0.0	0.0	1	1	0.0	0.0	0.0	0.0	1	1255

*Source: Table is developed from Tables 1, 2, and 3 in Appendix III.

From the above expression we can see that C is a matrix which consists of a row vector of prices 4/ and that X is a matrix of a column vector showing the level of output of the activities.

In linear programming problems, there are two general groups of activities, real activities and disposal activities. Real activities are those which produce a product for sale or purchase and use a commodity. Disposal activities are those activities which are included in the program to permit some available resources to go unused and to allow inequalities to be converted into equalities. Using the data in Table III-1 the objective function of that specific linear programming problem is stated as follows:

Maximize CX =

$$[266313,90000,54604,90000,212315,90000,0,0,0,0,0] \begin{bmatrix} AR_1 \\ ARL \\ BR_2 \\ BRL \\ DR_1 \\ DRL \\ Labor \\ Cash \\ ALAND \\ BLAND \\ DLAND \end{bmatrix}.$$

4/ The term prices refers to economic gain from a unit of activity. In the example problem, economic gain is defined as Net Return to Land and Family Labor (NRLFL).

AR_1, ARL, BR_2, BRL, DR_1, and DRL are real activities while Labor, Cash, ALAND, BLAND, and DLAND are disposal activities.

The row vector of prices represents the net return to land and family labor from a hectare of cropping activity or of a hectare of renting land to sugarcane factory. In this particular example, the prices of the real activities or outputs are positive while the prices of the disposal activities are assumed to be zero. To assume zero prices for disposal activities means that there is neither economic reward nor penalty from not using some or all of the resources available. The values of the real and disposal activities (AR_1 through DLAND) represented by the column vector are unknown. The purpose of solving the linear programming problem is to find the optimum level of these activities.

Alternative Activities

The X component of the first inequality, $AX \leq B$, has been discussed briefly, and the B component will be discussed in the next section. The A matrix is an $n \times m$ matrix, where n is the number of rows and m is the number of columns. The general form of the A matrix can be written as:

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1m} \\ a_{21} & a_{22} & \cdots & a_{2m} \\ \vdots & & & \\ a_{n1} & a_{n2} & \cdots & a_{nm} \end{bmatrix}.$$

In the specific data example in Table III-1, the A matrix is a 6 × 5 matrix:

$$A = \begin{bmatrix} 3057 & 7343 & 1354 & 7343 & 2237 & 7343 \\ 95467 & 0.0 & 34619 & 0.0 & 65205 & 0.0 \\ 1 & 1 & 0.0 & 0.0 & 0.0 & 0.0 \\ 0.0 & 0.0 & 1 & 1 & 0.0 & 0.0 \\ 0.0 & 0.0 & 0.0 & 0.0 & 1 & 1 \end{bmatrix}.$$

Each element in the A matrix represents an input-output coefficient of an activity; i.e., the amount of certain resources required to operate an activity at the level of one. For example, a_{13} is the third element in the first row of the A matrix and it represents the amount of labor required to operate one hectare of rotation BR_2. The labor required is 1,354 hours.

A bundle of resources is required to farm a hectare of land. For example, to farm a hectare of rice requires other inputs such as labor and cash capital. Therefore, a column vector in the A matrix represents a specific combination of inputs to produce one unit of an output. Thus,

the inequality $AX \leq B$ can be written in matrix form by using specific data in Table III-1 as in the following:

$$A = \begin{bmatrix} 3057 & 7343 & 1354 & 7343 & 2237 & 7343 \\ 95467 & 0.0 & 34619 & 0.0 & 65205 & 0.0 \\ 1 & 1 & 0.0 & 0.0 & 0.0 & 0.0 \\ 0.0 & 0.0 & 1 & 1 & 0.0 & 0.0 \\ 0.0 & 0.0 & 0.0 & 0.0 & 1 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \\ x_6 \end{bmatrix} \leq \begin{bmatrix} b_1 \\ b_2 \\ b_3 \\ b_4 \\ b_5 \end{bmatrix}.$$

The first column in the A matrix consists of a_{11}, a_{21}, a_{31}, a_{41}, a_{51}, and shows the amount of labor and cash capital required to farm one hectare of land type A using rotation AR_1. The 0.0 coefficients indicate that no land type B and D are required for rotation AR_1. Similarly, the second column represents the amount of resources required if one hectare of land type A is rented to the sugar mill, etc.

The first row of A consists of a_{11}, a_{12}, a_{13}, a_{14}, a_{15}, a_{16}, and shows the amount of resource b_1, labor required to farm one hectare of each AR_1, ARL, BR_2, BRL, DR_1, and DRL, respectively. Similarly, the second row represents the amount of capital required for a hectare of each activity.