AN ECONOMIC ANALYSIS OF OIL PALM FRUIT PROCESSING IN EASTERN NIGERIA

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ABSTRACT

AN ECONOMIC ANALYSIS OF OIL PALM FRUIT
PROCESSING IN EASTERN NIGERIA

by William Lloyd Miller

The oil palm industry is a major part of the Eastern Nigerian economy. It is characterized by many small production and processing firms.

Five major processing technologies, the hand method, the screw press, the hydraulic hand press, the pioneer oil mill, and the Stork major mill, are used to process palm fruit in the Eastern Region. The Regional Government has recently taken an active role in developing the palm industry by introducing several new programs in the 1962-1968 Economic Development Plan.

This study had the following objectives: 1) to determine the more efficient technologies and scales of operations, 2) to describe the present organization and operation of the processing system in terms of the prevailing physical coefficients and their associated prices, 3) and to suggest appropriate government policy in the palm processing industry.

The relationship between cost and volume for firms in the palm processing industry is examined with explicit reference to space as an important factor. Thus, the cost of transforming the raw material into a finished product is the sum of the cost of the raw material, transporting it to the plant, processing it, and distributing it to the consuming unit. Short run processing and transportation cost functions are budgeted

at four levels of output for each technology under the usual assumptions specified for a static competitive model.

Cross-sectional data were obtained from the samples of firms selected in each technology to develop the cost and revenue functions. Random samples of hand method and screw press processing firms were collected in two geographical areas selected in Eastern Nigeria. These areas were selected to represent the two dominate social and climatic regions in Eastern Nigeria where processing operations probably would be relatively homogeneous. Census of the private firms using the hydraulic hand press and the public firms using the pioneer oil mills in Eastern Nigeria provided the data to develop cost and revenue functions for these technologies. A case study of the only Stork major mill processing wild palm fruit in Eastern Nigeria was used to analyze this technology.

Analysis of these data provided the following information. As the size of plant increases less fruit and labor inputs are required to produce a ton of oil. Efficiency, defined as the value of output divided by the value of input, is similar for the screw press, the hydraulic hand press and the pioneer oil mill under a variety of budgeted conditions. As the size of plant increases the average variable cost component of average total cost declines in relative magnitude while the average fixed component increases. The average total cost is greater than average revenue for most levels of output per day and lengths of season described in the budgets.

The following conclusions were reached about appropriate government policy. If the screw press, the hydraulic hand press, and the pioneer oil mill are all used for processing palm fruit, efficiency in the palm processing industry will be maximized. Use of the hand method processing technology will maximize employment and minimize the value of capital imports. Use of the Stork mill will maximize the oil yield for export and income per capita of the employees. Changing the method for processing palm fruit for the export market from the screw press to the hydraulic hand press or the pioneer oil mill does not benefit the economy because advantages of higher oil exports are balanced by capital imports. Under the present price and cost relationships in Eastern Nigeria there is an overinvestment in the palm processing industry. Therefore, the government probably should not plan to make additional investments in processing equipment at this time.

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CHAPTER I

INTRODUCTION[1]

Description of the Oil Palm

The oil palm, *Elaeis guineesis*, thrives in tropical areas where the average rainfall is between 80 and 100 inches annually, the soil has a high clay content, temperatures are around 95°, and the humidity is above 80 per cent.[2] These climatic conditions are found in West Africa usually between 15° North and 10° South latitudes in a belt from the coastline to 150 miles inland. In the tropical forest wild palms may grow to a height of 80 feet. At the crown of the tree long feathery leaves with bunches of palm fruit in their axils radiate from the main trunk. The fruit bunches usually weigh from 10 to 50 pounds and contain from 200 to 2000 fruit clustered on long spikelets attached to a central stalk.[3] Each three-quarter inch in diameter olive shaped palm fruit yields a valuable commercial product, palm oil, when its fiberous pericarp

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[1] All weights, measures, and values reported in this thesis are based on the English system of exchange. For example, 1 ton = 2240 pounds, 1 hundredweight = 112 pounds, £ = $2.80 U. S., 1 shilling = s = $0.14 U. S., and 1 pence = d ≈ $0.01 U. S.

[2] "African Produce in the World Market", *Statistical and Economic Review*, No. 25, (June 1961), p. 45.

[3] W. D. Raymond, "The Palm Oil Industry", *Tropical Science*, Vol. 3, No. 2, (1961), p. 71.

is squeezed. Another valuable product, palm kernel, is found in a hard nut inside the pericarp layer.

The Importance of Palm Products to the Eastern Nigerian Economy

The two major commercial products of the palm industry, kernels and oil, provide Eastern Nigeria with food for the indigenous population, foreign exchange since they are the primary exports, and a significant proportion of government revenue.

Domestic use of palm products.--Within the Eastern Region oil is consumed by blending it with other foods, such as, yam, cassava, and rice.[4] As a supplement to these carbohydrate rich foods, oil provides a major part of each Nigerian's daily vitamin A requirement. Palm kernels which also supply vitamin A are roasted and eaten like groundnuts.

The importance of palm products exports in relation to total exports.--Palm oil and kernel exports to Europe are utilized primarily in the form of vegetable cooking oils and margarine. While the palm oil is ready to be blended, palm kernel oil first must be extracted from the kernels in the large processing plants located in Europe.[5] Extracting palm kernel oil creates a kernel meal by-product which is utilized in Europe as a supplementary feed in the livestock industry. Both palm oil and palm kernel oil find secondary uses as components in the manufacture of soap and candles and as a flux in the tin-plating

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[4] Ade N'Idu, "Nigeria's Palm Oil Industry", West African Review, (August, 1960), p. 39.

[5] Kernal processing plants are now being constructed in Nigeria.

industry.[6] Palm oil and palm kernels are the major export of the Eastern Region. In 1959, all major export products produced in Eastern Nigeria and shipped through its major ports were valued at £24,415,000.[7] The value of palm products exported during that year was £23,090,000 which is 94.6 per cent of the total value of all exports indicated above.[8]

The proportion of government tax revenue derived from palm products.--Palm products are a significant source of the tax revenue of the Eastern Region. During 1961, approximately 19 per cent of the total revenue of the Eastern Region came from produce purchase taxes and palm produce export duties which are the direct taxes on palm products.[9] If the indirect tax revenue generated by the palm industry could be determined, the per cent of tax revenue contributed by it would be higher than 19 per cent. The part of total income tax revenue generated by transactions in the palm industry is one example of an indirect tax of an unknown amount that could be attributed to the palm industry.

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[6] Daryll Forde, and Richenda Scott, The Native Economics of Nigeria, Vol. I of The Economics of a Tropical Dependency, ed. Margery Perham (2 vols.; London: Faber and Faber, 1946-48), p. 217.

[7] Derived from Eastern Nigeria, Ministry of Economic Planning, Statistical Digest of Eastern Nigeria, Official Document No. 22 of 1963, p. 57.

[8] Ibid.

[9] Nigeria, Federal Office of Statistics, Digest of Statistics, Vol. XIII, No. 1,(1964)

A Brief Description of the Organization of the Production Sector of the Palm Industry

The small scale social organization of oil palm tree ownership.--The oil palm in Eastern Nigeria is owned, maintained, and harvested predominately by small peasant farmers. Since it is a wild tree that is propogated by nature rather than by man, a variety of systems have developed to determine the ownership of products from a particular tree. The right to products usually is not related to the right to use the land on which the trees grow. People who have the right to cultivate annual crops on a particular parcel of land may have no right to the yield of palm trees growing on this land. The right to palm products usually resides with the head of a household (compound) which usually contains the head, his wives, children, unmarried brothers, widowed relatives, and servants. The head may acquire the right by inheriting the tree, by planting it, and by being granted its use by a larger element of society, such as, the village or a secret fraternity.[10] The head of a household may distribute his right to palm products to the members of his household and in return require the members of the household to accept certain obligations. For example, a wife may have the right to sell palm kernels and the obligation to process the palm fruit for her husband.

Cultural practices affecting maintenance of the palm tree.--Small farmers perform little direct maintenance for oil palms. The palms benefit somewhat from cultural practices, i.e.,

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[10] Anne Martin, The Oil Palm Economy of the Ibibio Farmer, (Ibadan: Ibadan University Press, 1956), pp. 3-11.

cutting weeds or spreading fertilizer, when these practices are applied to annual crops growing among the trees.

Social organizations affecting time of harvesting palm bunches.--The time palm trees are harvested is usually controlled by the head of the household, but sometimes a larger social unit, e.g., the village, controls the period of harvest. For example, the village elders may prescribe that no fruit can be harvested until the end of a three week period when they may require all members of the village to harvest and process the ripe fruit from all the palm trees. The returns from this harvest are collected as a local tax assessment.[11] This method of local tax collection is important to processors who depend upon this supply area for their fruit.

The minor role of palm plantations in Nigeria.--Plantations are not a major source of palm production because the British Colonial Government refused to permit private firms or government agencies to establish them in Nigeria. The only exceptions to this rule are a few thousand acres of land allocated to private firms for plantation production so improved palms for the native farms might be developed.[12] Recently the Eastern Nigeria Development Corporation has established plantations which will be discussed in more detail in the section of this chapter concerned with the Development Plan.

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[11] Ibid.

[12] Forde, op. cit., p. 227.

A Resume of the Marketing System for Palm Products

Separating palm fruit from the tree and the bunch.--Most palm fruit is harvested in Eastern Nigeria by peasant farmers who climb wild palm trees and cut the bunches of fruit out of the crown. After they harvest the bunches they are carried to the owners compound where the bunches are allowed to ferment in a damp place for from one to three days. Since fermentation weakens the stem that holds the fruit to the bunch the labor required to strip the fruit from the bunch is reduced. The advantage of lower labor requirements is offset by the disadvantage of lower quality oil because the proportion of free fatty acid in the palm oil increases during fermentation.[13]

Methods of processing palm fruit in Eastern Nigeria.--After the fruit has been removed from the bunch it is transported to a processing firm where it is pressed to extract the palm oil from the pericarp. The five processing technologies presently used in Eastern Nigeria are the hand method, the screw press, the hydraulic hand press, the pioneer oil mill, and the Stork major mill. The processing technologies range in size from the small hand method firms located in a home where only one farmer's harvest is processed to the large Stork major mill where the harvests of several hundred farmers are collected over a large supply area. It should be noted that only the Stork major mill

[13]Charlotte Leubuscher, The Processing of Colonial Raw Materials: A Study in Location, (London: HMSO, 1951), p. 35.

includes, as part of the processing system, equipment for removing palm fruit from the bunch.

The major role of the hand method and the screw press.--This study includes hand method and screw press processing technologies because at least 80 per cent of the oil exported and 90 per cent of the total palm oil produced in Eastern Nigeria come from these small scale firms. These minimum percentages were derived in the following manner. During 1961 and 1962 an average of 141,000 tons of palm oil were purchased annually by the Eastern Region Marketing Board.[14] Out of these 141,000 tons of oil, plantations produced 4,500 tons, 96 government owned pioneer oil mills produced approximately 16,500 tons and privately owned pioneer oil mills probably produced no more than 8,250 tons.[15] This leaves at least 111,750 tons or 80 per cent of the total oil exported that must have been produced by small scale processing firms. Since it has been estimated that palm oil exports are only one-half of total oil production, the average annual production of palm oil during 1961 and 1962 was approximately 282,000 tons.[16] Considering that large scale processing firms produced 29,250 tons of oil, it appears at

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[14] Federal Office of Statistics, op. cit., p. 73.

[15] Eastern Nigeria Development Corporation, Summary of Mills Account: 1961 and 1962 Fiscal Years, (Aba: Eastern Nigeria Development Corporation, June, 1963), pp. 1-4 (Mimeographed).

[16] M. Th. Zwankhuizin, Report from FAO Expert to the Government of Eastern Nigeria, (Enugu: By the author, April, 1963), p. 2. (Mimeographed).

least 252,750 tons or 90 per cent of the average annual production of palm oil in 1961 and 1962 came from small scale processing firms.

The functions of the small middlemen and the buying stations.--After palm fruit is processed by the hand method or the screw press the small batches of oil and kernels produced by each firm are purchased by middlemen. The middlemen combine the small batches into larger containers and transport the oil and kernels to buying stations which have been established throughout the oil palm region by licensed buying agents. At the buying stations the oil is heated and decanted to separate water and dirt from the oil while the kernels are dried and separated from broken shells and stones. The clean oil and kernels are placed in eight hundredweight metal drums and two hundredweight jute bags respectively for shipment to the ports. Palm products processed by other technologies are not handled by the small middlemen or the buying stations because they are cleaned and stored in large containers as part of the processing operation.

The function of the licensed buying agents.--The unadulterated palm products prepared at the buying station or the processing firms are transferred to the Eastern Region Marketing Board through a system of buying agents licensed by the Board. The Regional Marketing Boards are coordinated through the Nigerian Produce Marketing Company Limited. The number of buying agents is determined by the Board, and each buying agent must handle annually at least the minimum quantity specified by the Board. Through these methods of control, the Marketing Board negotiates with a small number of buying agents. The licensed buying agents are responsible for purchasing palm products, placing the products in appropriate containers, arranging for Marketing Board inspections, and transporting the products to the ports where they are purchased by the Marketing Board.

The functions of the Marketing Board.--The Eastern Nigeria Marketing Board establishes the prices paid to producers for produce intended for export from Nigeria. Through its licensed buying agents the Board purchases all produce offered at these prices which are based on prescribed grades and standards. The basic producer prices established by the Board for palm produce are listed in Table 1.1 for the years 1956 through 1964.

Table 1.1.-Eastern Region Marketing Board producer prices for palm oil and kernels at Port Harcourt 1956-1964[a]

Year	Palm Oil Grade[b]				Kernels
	SPO	I	II	III	
	-.s.d-	£			
1956	50. 0. 0	38	28	20	30
1957	50. 0. 0	38	28	20	30
1958	50. 0. 0	40	28	20	29
1959	47.15. 0	40	34	26	29
1960	47.15. 0	40	34	26	29
1961	47.15. 0	40	34	26	29
1962	40. 0. 0	34	30	26	25
1963	40. 0. 0	34	30	26	25
1964	41. 0. 0	35	31	26	27

a. Nigerian Produce Marketing Company Limited, Report on Produce Export, (Lagos: By the author, 1963) p. 13. (Mimeographed).

b. In 1964, palm oil classified as SPO, I, II, and III have a maximum free fatty acid content of 3 1/2 per cent, 9 per cent, 18 per cent, and 30 per cent, respectively.

A Review of the Government Programs for Palm Production and Processing During the 1962-1968 Development Plan

The palm production programs.--Since the Eastern Government has given a high priority to agriculture during the 1962-1968 Development Plan, several of the programs in the Plan which affect palm production and processing in the private and public sectors of the economy will have a significant impact upon the future structure of the palm industry.[17] The three Plan programs related to palm production are small holder palm grove rehabilitation, farm settlements and palm plantations. The palm grove rehabilitation program encourages small farmers to replace old wild palm trees with new improved hybrid palm seedlings which are provided free of charge. When the farmers plant and care for these seedlings in accordance with Ministry of Agriculture recommendations, they are given annual cash payments, free fertilizer, and technical assistance until the palms are 5 years old.[18] The Plan target is that 60,000 acres of the old trees should be replaced with new seedlings by the end of 1968.[19] The farm settlement program includes palm production as part of a broader agricultural program which includes several other crops and types of livestock. The settlements which are organized and financed by the Eastern Region will have 16,320 acres of oil palm

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[17]Eastern Nigeria, Ministry of Economic Planning, Eastern Nigerian Development Plan 1962-68, (Enugu, The Government Printer, 1962), p. 8.

[18]Ibid, p. 22.

[19]Eastern Nigeria, Ministry of Economic Planning, 1st Progress Report Eastern Nigeria Development Plan 1962-1968, Official Document No. 15, (Enugu, The Government Printer, 1964), p. 7.

trees.[20] The palm plantations will be managed by a quasi-government agency called the Eastern Nigeria Development Corporation. The five plantations presently being developed are located at Calaro, Kwa Falls, Biase, Eket, and Elele. The Plan proposes a target of 40,000 acres of oil palm for plantations.[21] The magnitude of government plans for palm production can be understood when the yield of the total 116,320 acres target is compared to the total annual oil export of Eastern Nigeria. If one ton of oil is produced per acre from the improved palm trees when they reach maturity the target acreage will yield annually about 83 per cent of the average annual exports of Eastern Nigeria from 1961 to 1964, i.e., 140,000 tons.[22]

The hydraulic hand press palm processing program.--There is one program in palm processing being financed during the 1962-1968 plan period. One thousand technically efficient small scale hydraulic hand presses were purchased by the Regional Government for sale to small processors.[23] It was anticipated that these presses would be adopted for use throughout the Region to increase the percentage of oil extracted from the palm fruit presently harvested. They also were to be used with the small holder rehabilitation program and the farm settlement program. This method of processing is one of the five methods evaluated in subsequent chapters of this thesis.

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[20] Ibid.

[21] Ibid.

[22] Nigeria Produce Marketing Company Limited, Oil Palm Purchases in the Federation of Nigeria 1949 to 1964, (Lagos: Nigerian Produce Marketing Co., 1963) p. 4.

[23] Progress Report, op. cit., p. 27.

Objectives of this Study

This research will provide information about the palm fruit processing system in Eastern Nigeria which is suitable as a guide for planning by public agencies and private businessmen. The information will be used to evaluate current problems, such as, the hydraulic hand press program. To properly analyze these practical problems, certain basic input and output coefficients and their associated costs and returns must be known for a wide range of processing and transportation operations. Therefore this research project has a broad framework designed to include the important variables affecting the operation of the processing sector.

This study has the following specific objectives: 1) to determine the more efficient technologies and scales of operations, 2) to describe the present organization and operation of the processing system in terms of the prevailing physical coefficients and their associated prices, 3) and to suggest appropriate government policy in the palm processing industry. The first objective is the primary objective of this study so the budgets developed in the following chapters will focus directly on this objective. The second and third objectives are secondary, but they will be treated in considerable detail in this study.

Summary

The palm industry is the major factor influencing the economy of the Eastern Region. It is characterized by many small production and processing firms. Several government programs are being introduced to develop both small scale and large scale production and processing firms. The primary objective of this research is to determine the more efficient technologies and scales of operations for palm oil processing plants.

CHAPTER II

METHODOLOGY

Introduction

This thesis examines the relationship between cost and volume for firms in the plam processing industry. The factors which underlie cost and volume are considered in a framework of analysis which explicitly recognizes space as an important factor. Thus, the cost of transforming a raw material into a finished product is the sum of the cost of the raw material, transporting it to the plant, processing it, and distributing it to the consuming unit.

First, this chapter describes the historical development of spatial theory. Second, it describes the general spatial problem and model. Third, it describes the simple spatial model. Finally, it describes in detail how the specific model used in this study synthesizes cost functions by budgeting.

The Historical Development of Spatial Theory

Why spatial theory developed.--Certain German economists explicitly introduced space as a major feature of their economic analysis during the 19th Century.[1] They introduced space partly as a criticism of English classical general equilibrium theory which

[1] J. F. Bell, A History of Economic Thought, (New York: The Ronald Press Company, 1953), pps. 292-97.

emphasized time rather than space in its analytical framework.[2] But the Germans emphasized space primarily because they thought classical theorists were ignoring an important explanatory factor. Three German economists, Thünen, Lösch, and Weber, who were interested in spatial theory, introduced space into their analysis in somewhat different ways. Their basic concepts of the role of space in economic theory are outlined briefly below.

Thünen's spatial theory.--Thünen[3] considered an isolated state where a city is located on a homogeneous fertile plane. Within the isolated state he demonstrated that agricultural production would be arranged in concentric circles about the city center. Bulky, perishable, low priced products would be produced near the central city while products with the opposite characteristics would be produced further from the city. Thünen's early illustration of the importance of spatial factors in determining the location of production led to his recognition as the forerunner of modern location theory.[4]

Weber's spatial theory.--Weber[5] examined the location of firms rather than the location of production. His spatial theory considered a plane with many consuming centers and deposits of raw materials. He was particularly concerned with two spatial factors,

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[2]Walter Isard, Location and Space-Economy, (New York: John Wiley and Sons Inc., 1956), p. 26-27.

[3]J. H. V. Thünen, Der Isolierte Staat (ed. H. Waentig, 1930).

[4]Eric Roll, A History of Economic Thought, (London: Faber and Faber Ltd., 1961), p. 329.

[5]Alfred Weber, Theory of the Location of Industries edited by Carl J. Friedrich, (Chicago: University of Chicago Press, 1929).

i.e., the loss or gain of weight by products during manufacture, and the agglomeration effects of concentrating production and consumption in one local area. He concluded that those products which lose weight during manufacture would be produced in plants relatively near raw materials while those products which gain weight would be manufactured relatively near the consuming center. He indicated that agglomeration forces such as the nearness to labor inputs and product buyers would encourage manufacturing plants to locate close to a city. But deagglomeration forces such as high land values would discourage the location of a manufacturing firm near a city. Some balance among the factors of weight loss, weight gain, agglomeration, and deagglomeration would determine the optimum location for a manufacturing industry.[6]

Lösch's spatial theory.--Lösch[7] divided a broad homogeneous plane with uniform transport features into hexagonal market areas. He used a set of mathematical equations to describe the operation of a simple static economy under monopolisticly competitive market conditions. Lösch is considered to be the first writer to include spatial features in a general equilibrium model of the economy.[8]

A list of recent contributions to spatial theory.--In recent years other economists have published books about location theory.

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[6]Richard G. Ford, "Theories of Plant Location", (Federal Extension Service, U. S. Dept. of Agriculture, Washington, (November 1962), p. 18.

[7]August Lösch, The Economics of Location, (New Haven: Yale University Press, 1954).

[8]Isard, op. cit., pps. 44-49.

At the risk of failing to mention all major contributions, it seems appropriate to bring specific attention to the books of Hoover[9], Dunn[10], Greenhut[11], and Isard[12]. Their contributions have expanded the theoretical framework and the empirical techniques available for analyzing manufacturing and transportation costs.

The General Spatial Problem and Model

The general spatial problem.--The general spatial problem may be characterized in the following manner. Visualize areas of raw material supply and finished product demand as broad planes surrounding a manufacturing plant. Within the supply plane there are small areas or points of high and low raw material density while within the demand plane there are areas of high and low consumer density.[13]

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[9] E. M. Hoover, The Location of Economic Activity (New York: McGraw-Hill Book Co., 1948).

[10] Edgar Dunn, The Location of Agricultural Production (Gainsville: University of Florida Press, 1954).

[11] M. L. Greenhut, Plant Location in Theory and Practice (Chapel Hill; University of North Carolina Press, 1956).

[12] Isard, op. cit., and Walter Isard, Methods of Regional Analysis: an Introduction to Regional Science (Cambridge: The Massachusetts Institute of Technology Press, 1960).

[13] Two excellent studies combining the supply area assembly cost and processing cost while holding the distribution cost fixed are:

Gene A. Mathia and Richard A. King, Planning Data for the Sweet Potato Industry: 3. Selection of the Optimum Number Size and Location of Processing Plants in Eastern North Carolina, Agricultural Economics Information Series No. 97, (Raleigh: Department of Agricultural Economics, North Carolina State College, December 1962) and

John F. Stollsteimer, "A Working Model for Plant Numbers and Location", Journal of Farm Economics, Volume XLV (August, 1963), pp. 631-45.

Assume that the location of each small area or point and the quantity supplied or demanded there at a given price are known. Then if appropriate transportation costs are known, it is possible to compute the cost of assembling raw materials and distributing the finished product for any particular plant location and level of plant output.[14]

Why a comprehensive model was simplified.--Recent developments in mathematical programming and computer technology have made transportation cost computations of the magnitude indicated above feasible when detailed data can be obtained. Since the problems of determining the optimum plant size, location and number to minimize the combined cost of assembly, processing, and distribution are interrelated, their simultaneous mathematical solution is clearly required. The original research plan for studying the palm processing industry in Nigeria was simultaneously to solve these three problems. But it soon became apparent that the volume of information needed to use this comprehensive model was neither available in Nigeria nor obtainable with the resources available for this study. Adequate information on the location of production or even on the total quantity of palm fruit produced in Eastern Nigeria was not available. Although the needed information was not available, the planning problems in palm processing still remained. So a partial analysis with more simplifying assumptions than would be necessary in a comprehensive

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[14] A study which permits all three costs, i.e., assembly, distribution and processing, to vary is reported in:

Gordon A. King and Samuel H. Logan, "Optimum Location, Number and Size of Processing Plants with Raw Product and Final Product Shipments", Journal of Farm Economics, Volume XLVI (February, 1964), pp. 94-108.

model was used for this study.[15] When additional data are available about the location of raw material supplies, these data can be combined with the information developed in this study for a more rigorous analysis of the problem.

A Simple Spatial Model

The assumptions which simplify the determination of raw material assembly cost.--The simple spatial model combines assembly cost and processing cost for a palm processing plant to solve the problem of optimum plant size without solving the problems of plant location or plant number. The following assumptions describe how the transportation portion of the problem is simplified. For many purposes the average production density in the supply plane can be used to estimate the cost of assembling fruit for processing. If transportation facilities are assumed to be continuous and the terrain is assumed to be uniform, then the cost of assembling fruit will be minimized by drawing from a circular supply area. Under these assumptions as the output of a processing plant increases the average distance fruit must be transported and the average cost of fruit increase.[16]

Nigerian conditions which simplify the determination of product distribution cost.--The Nigerian palm oil marketing system has a

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[15] The problem of inadequate data seems to be a general one in underdeveloped areas. For example, see

Clifton R. Wharton Jr., "Processing Underdeveloped Data from an Underdeveloped Area", Journal of the American Statistical Association, Vol. 55 (March, 1960), p. 37.

[16] D. C. Williamson, "The Equilibrium Size of Marketing Plants in a Spatial Market", Journal of Farm Economics, Vol. XLIV, (Nov., 1962), p. 954.

unique feature which permits simplification of product distribution costs. The individual processor using a given technology sells in a market where the demand function for his product is perfectly elastic. In any year, he can sell any quantity of output for a constant price because the Eastern Region Produce Marketing Board establishes a minimum price for palm oil and kernels at village buying stations located throughout the Region. Under these conditions the distribution cost for a processor will not increase when the output of his plant is increased. The assumptions described above simplify both the assembly and distribution portion of this problem. Under these conditions it is necessary to determine only the cost for assembling palm fruit by the three major methods of transportation used in Eastern Nigeria, i.e., headload, bicycle, and lorry.

Other assumptions which apply to the estimation of both transportation and processing cost functions.--There are other assumptions which apply to the estimation of both the transportation and processing cost functions. These assumptions are described below. The short run cost and revenue functions are developed in a competitive static model.[17] The price paid for a factor of production is independent of the quantity of the factor used. For example, labor is purchased by the firm in a market with a perfectly elastic supply function for each class of labor, and fruit is purchased at a constant price at local assembly points within the supply area. Rational behavior and a goal of maximizing returns are assumed for all processing and transportation firms.[18] In the short run it is possible

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[17] Ibid., pp. 953-57.

[18] T. W. Schultz, Transforming Traditional Agriculture, (New Haven: Yale University Press, 1964), p. 164.

to vary fruit and labor inputs, but the plant size is held fixed.

Synthesis of the Short Run Cost Functions

Economic implications of the method of synthesis.--The following section describes in detail how data on assembly and processing costs are developed. Costs on both functions are developed by budgeting data collected from samples of firms representing each assembly and processing technology.[19] The budgets are prepared by assuming that the average input to output ratios obtained from the samples of firms are constant at all relevant levels of output. This method of synthesis implies that fruit and labor are perfect complements for each technology, that the production function is linear, and that the joint marginal product of the two complements equals their joint average product.

Definition of the subdivisions of total cost.--In some of the following chapters about the processing technologies, total cost of production is divided into as many as four subdivisions to illustrate important relationships among these subdivisions. The

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[19] Among the many sources discussing and demonstrating methods of data collection, the ones found most useful in this study are listed below:

L. L. Sammett and B. C. French, "Economic-Engineering Methods in Marketing Research", Journal of Farm Economics, Volume XXXV (December, 1953), pp. 924-31.

J. F. Stollsteimer, R. G. Bressler, and J. N. Boles, "Cost Functions from Cross-Section Data - Fact or Fantasy", Agricultural Economics Research, Volume XIII (July, 1961), pp. 79-89.

W. R. Henry, J. S. Chappell, and J. A. Seagraves, Broiler Production Density, Plant Size, Alternate Operating Plans, and Total Unit Costs, Technical Bulletin No. 144 (Chapel Hill: North Carolina Agricultural Experiment Station, 1960).

subdivisions of total cost are labeled fixed processing cost, variable processing cost, general processing cost and assembly cost. The fixed processing cost is defined as the cost a firm must incur whether output is zero or greater than zero. In this study it includes depreciation and interest on investment based on the replacement cost of the fixed equipment. The remaining three subdivisions of cost, variable processing cost, general processing cost, and assembly cost are defined as costs a firm must incur only if output is greater than zero. The variable processing cost includes both the cost of fruit and unskilled labor which vary linearly and directly with output per day. The general processing cost includes items, such as, the cost of repairs and supervisory labor which are considered not to vary directly with output per day. The assembly cost includes all the cost items associated with assembling the fruit for processing. The assembly cost varies directly with output per day, but it does not vary linearly with output per day.

How the short run cost functions are combined.--The short run cost functions developed are combined in the following manner. The average variable and fixed cost functions for each transportation technology are summed vertically to establish the average total assembly cost function. The average total assembly cost functions for each transportation method are compared to determine the least cost transportation method for each level of processing firm output.[20] Then, for each of the five processing technologies, the least cost

[20] Ben C. French, "Some Considerations in Estimating Assembly Cost Functions for Agricultural Processing Operations", Journal of Farm Economics, Volume XLII (November, 1960), pp.. 767-79.

average total assembly cost function is added to the average variable processing cost function, the average general processing cost function, and the average fixed processing cost function to establish the short run average total cost function. This method of synthesis implies that processing and assembly costs are independent so they can be vertically summed.[21]

Summary

This chapter has traced the development of a method of analysis which considers the relation of cost to volume with explicit reference to space. Then, it has shown the simplifying assumptions necessary to adapt the analysis to the Nigerian oil palm industry and the dearth of data about that industry. Finally, it has described in detail how the short run cost data used in this analysis are developed through budgeting.

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[21]Williamson, loc. cit.

CHAPTER III

ASSEMBLY COST

Introduction

Definition of assembly cost.--This chapter develops the cost of assembling palm fruit by headload, bicycle, and lorry. The assembly cost for each of these three transportation technologies is composed of variable and fixed cost components. The variable cost of assembly is determined by the distance traveled, the speed of travel, the quantity transported, the waiting time, and the price of inputs. The fixed assembly cost is determined by the type of equipment used and the price of this equipment. The sum of the fixed and variable assembly cost is the total cost for assembling palm fruit.[1]

The order of development of this chapter.--The following sections of this chapter develop the cost of assembly in the following sequence. First, each transportation technology is considered in the following order: headload, bicycle, and lorry. Second, within each transportation technology the variable and the fixed costs of assembly are discussed. Third, the relation among the average length of haul, fruit production density, and the cost of assembly is considered. Fourth, the three transportation technologies are compared for several levels of processing plant output.

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[1]French, loc. cit.

Source of these data.--A survey was conducted at a pioneer oil mill in Okigwi Division to determine the cost of transporting from local assembly points, e.g., a home or a market, to the mill by headload. Since determining the assembly cost by interviewing people carrying fruit had proven unsatisfactory during questionnaire pre-tests, in this survey the times, distances, and volumes were measured and recorded by enumerators who accompanied the people carrying fruit.

The Headload Method of Fruit Assembly

Variable physical input coefficients.--A sample of forty persons transporting fruit by headload was obtained during the survey. These people transported an average load of 56 pounds of fruit, at an average speed of four miles per hour. The average time to load fruit, unload it, and wait at the mill was 15 minutes for each 56 pound load of fruit transported. These physical input data are used to develop the cost of transportation.

Why standard prices are used for variable inputs.--Each of the people who transported fruit owned the fruit being transported. About 75 per cent of the people harvested fruit from their own trees and transported it to the mill. The remaining 25 per cent purchased fruit from neighbors in their village and brought it to the mill to sell. Under these conditions they were unable to separate transportation costs from the overall profit obtained from harvesting or buying the fruit and selling it. Therefore variable assembly costs were determined in this study by applying a standard wage rate to the time required to assemble fruit. Since headload transportation of palm fruit throughout the Eastern Region of Nigeria is predominately done by women, the standard wage of 1s 6d per day developed from the surveys of processing operations is used to determine assembly cost (see Table 3.1).

Table 3.1.-Standard prices of variable transportation inputs in Eastern Nigeria, 1964

Variable transport input	Standard price
Woman carrying headload	1s 6d per day
Man riding bicycle	3s per day
Man assisting lorry driver	3s per day
Lorry driver	5s per day
Diesel fuel[a]	2 1/3d per mile
Oil[b]	1/3d per mile

a. This price assumes fuel costs 2s 9d per gallon and lorries use one gallon for every 14 miles of travel.

b. This price assumes oil costs 6s per quart and lorries use one quart every 200 miles traveled.

Fixed cost.--In order to use a consistent method of cost analysis the fixed cost of transportation equipment for the headload technology is included in this analysis. But it is so small in relation to variable cost that including or excluding it would not change the average total cost per unit of oil produced by ± 1d for any level of output considered here. The cost of an enamel headpan is listed as 5s 6d in Table 3.2. By using a straight line depreciation method and an average life of three years for calculation, the annual depreciation is 1s 10d. When the annual depreciation is added to the interest on investment of 3d to determine the total annual fixed cost for transportation, a total of 2s 1d is obtained. The annual fixed and general transportation cost for each transportation technology is listed in Table 3.3.

Table 3.2.-Fixed equipment inputs and cost for transportation methods in Eastern Nigeria, 1964

Transport method	Item	Replacement cost of each	Estimated life	Annual depreciation[a]
		£.s.d	years	£.s.d
Headload	Enamel headpan	0. 5. 6	3	0. 1.10
Bicycle	Bicycle	16.15. 0	9	1.17. 3
	Jute bag	0. 3. 0	1	0. 3. 0
Lorry	Six ton lorry	1349.11. 0	3	449.17. 0
	Three ton lorry	1000. 0. 0	3	333. 6. 8

a. Straight line depreciation method is used here, i.e., total investment divided by estimated life.

The Bicycle Method of Fruit Assembly

Variable physical input coefficients.--In order to obtain information about bicycle transportation costs, a sample of 16 bicycle transportation units were observed while they assembled fruit for processing at a pioneer oil mill in Okigwi Division. The bicycle riders carried an average load of 81 pounds of fruit while traveling at an average speed of six miles per hour. It required an average time of 15 minutes per load to load the fruit, unload it, and wait at the mill. The rate of speed for bicycle transport seems low when it is compared to the headload transport technology. This apparent

Table 3.3.-Annual fixed cost and general cost for transportation methods in Eastern Nigeria, 1964

Item	Headload	Bicycle	Lorry 3 ton	Lorry 6 ton
	£.s.d			
Fixed cost				
Depreciation on equipment[a]	0. 1.10	2. 0. 3	333. 6. 8	449.17. 0
Interest on investment[b]	0. 0. 3	0.11.10	35. 0. 0	47. 4. 8
General Cost				
Repairs[c]	d	1.15. 4	211. 1.10	284.17. 7
Insurance	d	d	127. 0. 0	198. 0. 0
Licenses[e]	d	0.10.0	84. 0. 0	104. 0. 0
Road worthiness inspection	d	d	70. 0. 0	70. 0. 0
Total	2. 1	4.17. 5	860. 8. 6	1153.19. 3

a. This is listed in Table 3.2.
b. This item is 7 per cent of one-half the replacement cost.
c. This item is 21.11 per cent of the price of lorries and 10.55 per cent of the price of bicycles.
d. Not applicable.
e. Bicycle license rates vary by local muncipality. Lorry license rates are for the Eastern Region.

discrepancy can be explained by the rolling terrain which often forces the bicycle rider to dismount and push his bicycle up hill which decreases the overall rate of speed.

Why standard prices are used for variable inputs.--All of the bicycle riders owned the fruit they brought to the mill. Fruit was collected from the owners own trees by 88 per cent of the owners and purchased from neighbors by the remaining 12 per cent. Since this situation is similar to the headload transport where it is difficult to separate the cost of transport from the overall profit or loss associated with buying and selling the fruit, it is treated in an analogous manner. The total time required to assemble the fruit is multiplied by the standard wage for men of 3s per day to determine the variable cost of fruit assembly.

Fixed cost.--A straight line depreciation method is used in Table 3.2 to determine the annual fixed depreciation charge for the bicycle and the jute bag. The annual depreciation charge of £2. 0. 3 is added to charges of £0.11.10, £1.15. 4, and £0.10. 0 for interest on investment, repairs, and licenses, respectively, to determine the total annual fixed and general cost for transportation (see Table 3.3).

The Lorry Method of Fruit Assembly

Variable costs.--The data on lorry operations were obtained from two private firms operating processing mills in the Eastern Region. These firms owned two six ton lorries and four three ton lorries which they used to collect fruit for their mills from local assembly points. The three-ton lorries observed were used for fruit assembly and for delivering oil and kernels to the port for sale. The six ton lorries had special tipping boxes and were used only to collect fruit for the mill. The variable operating charges for both six and three ton lorries are listed in Table 3.1. These charges were 3s per day for the assistant, 5s per day for the driver, 2 1/3d per mile for fuel, and 1/3d per mile for oil.

Depreciation rate.--The replacement cost for each size of lorry is listed in Table 3.2. The three year life expectancy for the lorries listed in Table 3.2 is an optimistic estimate based upon the actual experience of these private firms. Other sources which suggest a one and one-half to two year life for lorries in Nigeria consider primarily lorries used for long hauls at high speeds.[2] Since lorries used to collect palm fruit are driven at lower speeds for shorter distances, they would be expected to have a longer life than lorries in general use.

Fixed costs.--The annual fixed and general costs listed in Table 3.3 for the six ton lorry consist of 449.17. 0 for depreciation on equipment, £47. 4. 8 for interest on investment, £284.17. 7 for repairs, £198. 0. 0 for insurance, £104. 0. 0 for licenses, and £70. 0. 0 for road worthiness inspection. Tires and tubes are included in the repair costs rather than under variable operating costs because the proportion of total repair cost to allocate to tires and tubes was not available. The total annual fixed and general cost for six ton lorry transport is £1153.19. 3.

The Density of Fruit Production

The relation of average length of haul to density of fruit production.--The next step in the sequence used here to develop the total cost of assembly is relating the cost of the three transportation technologies to the average length of haul. As is indicated in Chapter II, it is assumed that the fruit will be assembled from a circular supply area with the mill located in the center of the circle.

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[2]Nigeria, Federal Ministry of Commerce and Industry, Transportation: A Guide to Current Costs in Nigeria, (Lagos: Federal Ministry of Information, June, 1964), p. 9.

In this situation the average length of haul is inversely related to the density of fruit in the surrounding area and directly related to the quantity of fruit processed.

<u>How fruit density is estimated</u>.--The density of wild palm fruit produced in the major palm production areas of Eastern Nigeria is unknown. But this fruit density can be estimated from the information secured in the Abak and Okigwi Division processing plant surveys. The quantity of palm fruit processed by each technology is calculated and then summed for all technologies in each division. When this sum is divided by the area in each division, the average fruit density of the division can be determined. When these calculations are carried out they yield an average fruit density of 25 hundredweight of fruit per square mile per day during March for Okigwi Division and an average density of 16 hundredweight per square mile per day in Abak Division.

<u>How annual variation in fruit density is controlled</u>.--Since palm trees yield more fruit in March than in any other month of the year, the average annual fruit density would be lower than indicated above during the rest of the year. But when density declines processing plants maintain a relatively constant level of fruit input per day by reducing the number of days per month that they operate. Similarly the transportation units assemble similar quantities of fruit per day over about the same average length of haul by simply reducing the number of days they operate per month. Under these conditions, the average fruit density can be treated as constant and equal to the March fruit density for the entire year for purposes of computing fruit assembly costs.

Conclusions

Differences between this chapter and following chapters.--The final step needed to develop assembly cost data is to calculate the average cost per hundredweight of oil produced for each transportation technology. The following relationship is used to determine the total variable daily assembly cost:

$$TVAC = Q\left(a + \frac{2}{3}\, b\, K \frac{\sqrt{Q}}{\sqrt{D}\;\sqrt{\pi}}\right)$$

The symbols in the formula above have the following definitions: TVAC = total variable assembly cost; Q = quantity of fruit assembled; a = a constant cost per hundredweight of fruit for loading fruit, unloading fruit, and waiting at the plant; b = a constant cost per hundredweight of fruit for labor, gasoline, and oil; K = a coefficient relating road distance to air miles; D = the average density of fruit produced in the area surrounding the plant; and π = 3.1417.[3] The following relationship was used to determine the total fixed and general daily assembly cost:

$$TFAC = \frac{AFAC}{L}$$

The symbols in the formula above have the following meanings: TFAC = total fixed and general assembly cost, AFAC = annual fixed and general assembly cost, L = length of season measured in days.

To facilitate comparison of assembly cost among the three transportation methods, several factors are held constant in Table 3.4 which will vary among processing technologies in the following chapters. Therefore, the assembly costs listed in Table 3.4 are not directly

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[3] French, op. cit., p. 771

applied in the following chapters. Instead the transportation cost for each processing technology is calculated separately by the method described above.

The most efficient transportation method for assembling palm fruit.--Under the conditions specified in this chapter, the headload method of transport has the lowest cost per hundredweight of oil processed for all the levels of output per day examined in Table 3.4 except the output level of 40 hundredweight. The cost for headload transportation ranges from a low of 11d to a high of 33d per hundredweight. Since the range of output per day considered includes all processing technologies except the hand method, one must conclude that the headload method of transport is the most economical method for processing plants to use under current conditions. One factor which underlies the low cost for headload transport presented in Table 3.4 should be considered when evaluating the most economical transport method. The difference in the 1s 6d per day wage for women and the 3s per day wage for men makes headload transport cheaper than bicycle transport. If men were hired at 3s per day to carry the headloads, then the average asembly cost per hundredweight of oil processed illustrated for the headload transport method would be doubled. Under these conditions the bicycle transportation method which costs from 19d to 35d per hundredweight of oil processed would become the cheapest transportation method for the range of output indicated above.

The direction of change if constants are varied.--The impact of changes in the various conditions established in this chapter upon the most economical transportation method can be briefly

Table 3.4.-The average total assembly cost for a hypothetical processing operation in Eastern Nigeria, 1964[a]

Type of transportation	Hundredweight of oil produced in eight hours 1	5	10	20	40
	----------pence per hundredweight of oil--------				
Headload	11	16	20	25	33
Bicycle	17	20	23	28	35
Six ton lorry	1250	251	126	63	32

a. This Table is derived from Tables 3.1, 3.2, and 3.3 based upon conditions which vary in the following chapters, but which are held fixed here for comparison of transportation methods, e.g., a 250 day operating season, a 6:1 fruit:oil extraction ratio, and a 20.5 cwt. of fruit per square mile per day production density.

summarized as follows. As wages increase, as the length of season increases, and as the quantity of palm produced per day increases, the transportation cost advantage shifts toward the lorry transportation method. Conversely, changes that are the opposite of these will shift the cost advantage toward the headload transportation method.

Summary

This chapter developed the cost of assembling palm fruit by headload, bicycle, and lorry. The headload method is the lowest cost assembly method per unit of oil output for the levels of output of most processing technologies used in Eastern Nigeria. It costs from 11d per hundredweight of oil produced by small processing firms to 33d per hundredweight of oil produced by large processing firms.

CHAPTER IV

THE HAND METHOD PROCESSING TECHNOLOGY

Description of the Processing Operation

The hand method of processing can be described as consisting of three or four separate stages which are based on operations that occur to the fruit as it flows through the plant. Plants that use four stages of processing sterilize the fruit, pound it, separate nuts from the fruit fibre, and press the fruit fibre. Plants that use three processing stages combine the separation of nuts with pressing the fibre. Each stage of processing is described below. (Stage one - sterilization) Women or children place the fruit in a small iron or earthen pot, add water to the pot, and heat it over an open fire. This destroys the enzymes which accelerate the development of free fatty acids. (Stage two - pounding) After the fruit is sterilized by steam it is placed in a small wooden mortar and pounded with a wooden pestle until the outer pericarp is crushed and partly separated from the fruit. (Stage three - separation) The pounded fruit is placed in a small wooden boat or an enamel pan and the oil saturated pericarp fibre is separated from the nuts by hand. (Stage four - pressing) In the final stage the crushed pericarp fibre is squeezed between the palms of the operator's hands to extract the oil.

The Sample Studied

Geographical location.--Samples of hand method firms were chosen independently in each of two geographic areas selected in Eastern Nigeria, i.e., in Abak and Okigwi Divisions. These areas were selected to represent the two dominate social and climatic regions in Eastern Nigeria where processing operations would probably be relatively homogeneous. Okigwi Division which is inhabited by Ibo speaking people is located approximately 140 miles from the sea in the deciduous forest vegetation zone where an average of 80 inches of rain falls annually. Abak Division which is inhabited by Ibibio speaking people is located approximately 40 miles from the sea in the rain forest vegetation belt which has an average annual rainfall of 100 inches.

Method of sample selection.--In each Division samples were drawn by a two-stage sampling technique. In the first stage, a random sample of voter registration wards was selected from the 1962 voter registration lists. Voter registration wards instead of villages were used as geographical sampling units because the wards are smaller political subdivisions and the councilor elected from each ward is familiar with the people in his small area. A councilor with intimate knowledge of the local people was needed to identify and locate processing firms and to assure the people that their processing equipment was not going to be taxed. Since a different number of firms were found in each ward selected in stage one, in stage two a proportionate sample of hand method operations was selected from each ward. This procedure gave each processing firm in the Division the same chance of being in the sample.

Method of data collection.--The following procedure was used to obtain the needed physical input and output data and price information at the site of each processing firm. Before the fruit was processed, the interviewer weighed it and recorded the weight on the questionnaire. During each stage of processing, a record was made of the number of workers employed and the time required to perform each task. After the processing operation was completed the oil and kernels were weighed and the weight was recorded. The physical input and output information obtained through direct measurement was supplemented by price information obtained by interviewing the operator of the processing firm. Both direct measurement and interview methods of data collection were employed because these small firms keep no written records of their operation.

Description of the Firms Surveyed

Characteristics of firm operations.--The hand method processing firms sampled had the following characteristics. The 34 firms sampled in Abak Division out of a total population of 14,280 firms operated an average of 31 days per annum and produced an average of .30 hundredweight of oil per day. The fruit was purchased by 94 per cent of the firms while the remaining 6 per cent used fruit harvested from the family trees. The oil produced by these firms was utilized in three ways: 6 per cent of the firms consumed the oil in their own homes, 12 per cent of the firms sold the oil and 82 per cent of the firms consumed part of the oil and sold the remaining portion. The 33 firms sampled in Okigwi Division out of a total population of 25,740 operated an average of 40 days annually and produced an average of .10 hundredweight of oil per day. Fifty-six per cent of these firms consumed the oil in their homes and 10 per cent of the firms sold the oil. The remaining 34 per cent disposed of their oil through both consumption and sale.

Description of labor inputs.--In both Divisions, women and children are the primary sources of labor employed to process palm fruit by hand. This family labor is usually not paid a wage but are paid, instead, shares in the overall returns derived from producing, processing and marketing palm products. Sometimes, labor is exchanged between neighbors, and, occasionally, a person is hired to conduct a specific operation, i.e., they are hired for piece work. The distribution of the labor by operating stages is indicated in Table 4.1.

Table 4.1.-Average labor inputs for hand processing in Abak and Okigwi Divisions, 1964[a]

Stage of Operation	Average woman day equivalent labor inputs per hundredweight of oil produced	
	Abak Division	Okigwi Division
Sterilization	1.5	1.3
Pounding	1.3	2.4
Separation	4.5 (Separation and Pressing combined)	5.2
Pressing		2.2
Total	7.3	11.1

a. One woman day equivalent equals eight woman hours or 32 child hours.

The firms located in Abak Division combine both separation and pressing into one operation. In Abak and Okigwi Divisions, respectively, an average of 7.3 and 11.1 woman day equivalents were used to produce one hundredweight of oil. This difference in labor efficiency occurs because a three stage processing method is used in Abak Division while a four stage method is used in Okigwi Division.

Budgeted Costs and Revenue

Average variable processing cost and revenue.--The budgets in Tables 4.2 and 4.3 show that an average hand method operation

Table 4.2.-Components of average variable processing cost and average revenue for hand method processing firms in Abak Division, 1964

Item	Quantity per cwt. of oil produced[a]	Price of item per unit	Value per cwt. of oil produced
		---s.d---	
Fruit	6.1 cwt.	6. 6 per cwt.[b]	39. 8
Labor	7.3 woman day equivalents[c]	1. 6 per day[d]	10.11
Average variable processing cost			50. 7
Oil	1.0 cwt.	34. 5 per cwt.[a]	34. 5
Nuts	4.0 cwt.	3. 9 per cwt.[e]	15. 0
Average revenue			49. 5

a. Each of these items is the average for the firms surveyed.
b. Standard fruit prices are used for each of three locations, i.e., 6s 6d in Abak Division, 6s 3d in Eastern Nigeria, and 6s 0d in Okigwi Division.
c. One woman day equivalent equals eight woman hours or 32 child hours.
d. This standard unskilled labor price is applied for all technologies operating anywhere in Eastern Nigeria.
e. Standard nut prices are used in each of three locations, i.e., 3s 7d in Okigwi Division, 3s 8d in Eastern Nigeria and 3s 9d in Abak Division.

Table 4.3.-Components of average variable processing cost and average revenue for hand method processing firms in Okigwi Division, 1964

Item	Quantity per cwt. of oil produced[a]	Price of item per unit	Value per cwt. of oil produced
		------------s.d------------	
Fruit	6.9 cwt.	6. 0 per cwt.[b]	41. 5
Labor	11.1 woman day equivalents[c]	1. 6 per day[d]	16. 8
Average variable processing cost			58. 1
Oil	1.0 cwt.	29. 2 per cwt.[a]	29. 2
Nuts	3.8 cwt.	3. 7 per cwt.[e]	13. 7
Average revenue			42. 9

a. Each of these items is the average for the firms surveyed.
b. Standard fruit prices are used for each of three locations, i.e., 6s 6d in Abak Division, 6s 3d in Eastern Nigeria, and 6s 0d in Okigwi Division.
c. One woman day equivalent equals eight woman hours or 32 child hours.
d. This standard unskilled labor price is applied for all technologies operating anywhere in Eastern Nigeria.
e. Standard nut prices are used in each of three locations, i.e., 3s 7d in Okigwi Division, 3s 8d in Eastern Nigeria and 3s 9d in Abak Division.

would have an average variable processing cost that is greater than average revenue. Under what conditions are these budgets related to the fact that hand method firms are in operation? A standard wage rate is used for labor inputs in this study because the primary objective is to compare the five different processing technologies. While 1s 6d per day is the standard wage an entrepreneur pays a woman to work at his processing firm, it is not the opportunity cost of a woman's daily labor input for processing at her home. The opportunity cost of her labor at home is equal to the difference between the wage which she can earn away from home and the cost of working away from home.[1] Working away from home includes costs, such as, arranging for the care of small children, being unable to supervise the work of older children, being unable to prepare meals at the same time and over the same fire that is used for fruit sterilization, and the cost of traveling to and returning from work. If the cost of working away from home is at least 2d per day and 1s 5d per day in Abak and Okigwi Divisions respectively, these home operations could continue operating until the equipment wears out.

Annual fixed processing cost.--The equipment requirements listed in Tables 4.4 and 4.5 are derived from the firm surveys

Table 4.4.-Equipment requirements and equipment cost for the Abak Division hand method processing firms, 1964

Item	Number required	Estimated life	Replacement cost of each	Total investment	Annual depreciation
		years	£.s.d		
Wooden mortar	1	7	0.16. 9	0.16. 9	0. 2. 5
Basket	2	1	0. 0. 9	0. 1. 6	0. 1. 6
Clay pot	2	1	0. 2. 2	0. 5. 0	0. 5. 0
Wooden spoon	1	2	0. 0.11	0. 0.11	0. 0. 5
Pounding stick	1	1	0. 0. 6	0. 1. 6	0. 1. 6
Enamel dish pan	2	3	0. 5. 6	0.11. 0	0. 3. 8
Wooden tray	1	3	0. 3. 0	0. 3. 0	0. 1. 0
				1.19. 8	0.15. 6

a. Straight line depreciation method, i.e., total investment divided by estimated life.

[1] This assumes the return from palm processing is greater than the return from alternative employment opportunities at home.

Table 4.5.-Equipment requirements and equipment cost for the Okigwi Division hand method processing firms, 1964

Item	Number required	Estimated life	Replacement cost of each	Total investment	Annual depreciation[a]
		years		£.s.d	
Wooden mortar	1	7	0. 8. 2	0. 8. 2	0. 1. 2
Basket	2	1	0. 1. 1	0. 2. 2	0. 2. 2
Clay pot	2	1	0. 2. 4	0. 4. 8	0. 4. 8
Wooden spoon	1	2	0. 0. 9	0. 0. 9	0. 0. 4
Pounding stick	1	1	0. 1. 1	0. 1. 1	0. 1. 1
Total				0.16.10	0. 9. 5

a. Straight line depreciation method, i.e., total investment divided by estimated life.

conducted in each Division. The estimated life is a standard value derived from considering the suggestions given by equipment owners in both Divisions. The price of each item is the operator's estimated average price of purchasing a new item of the described equipment. The total investment in equipment is £1.19. 8 in Abak Division and £0.16.10 in Okigwi Division. Total annual depreciation is calculated by dividing total investment of each item of equipment by the estimated life of that equipment. The annual depreciation in Abak Division is £0.15. 6 and in Okigwi Division is £0. 9. 5. The total annual fixed cost which is composed of the depreciation on equipment and the interest on investment is 6s 9d in Abak Division and 4s 0d in Okigwi Division (see Table 4.6).

Table 4.6.-Annual fixed cost for hand method processing firms in Abak and Okigwi Divisions, 1964

Item	Abak Hand Method	Okigwi Hand Method
	s.d	
Depreciation on equipment[a]	6. 2	3. 9
Interest on investment[b]	0. 7	0. 3
Total annual fixed cost	6. 9	4. 0

a. This is 40 per cent of total annual depreciation because the equipment is used 60 per cent of the time for work other than palm processing.

b. This is 7 per cent of one-half the 40 per cent of total investment in equipment allocated to palm processing.

Average total processing cost.--The two important related aspects of the cost functions illustrated in Tables 4.7 and 4.8 are the proportion of average variable processing cost to average total cost and the decrease in average total cost as output per day and length of season increase. Since average variable processing cost is at least 96 per cent of average total cost in both Divisions at the average daily level of output, the average fixed processing cost and the average assembly cost have very little impact on average total cost. When both the quantity of output per day and the length of season are increased in Abak Division, average total cost declines only from 52s 2d to 51s 7d per hundredweight of oil produced. Similarly in Okigwi Division if the lowest level of firm output is excluded, average variable cost per hundredweight declines only from 59s 11d to 59s 1d as the daily output and length of season increase.

Table 4.7.-Budgeted average cost for the Abak Division hand method processing firms, 1964

Item	Hundredweight of oil produced per eight hour day			
	.20[a]	.30[b]	.40[c]	.90[d]
	s.d			
Average variable processing cost[e]	50. 7	50. 7	50. 7	50. 7
50 day season				
Average fixed processing cost[f]	0. 8	0. 5	0. 4	0. 2
Average assembly cost[g]	0.11	0.11	0.11	1. 0
Average total cost	52. 2	51.11	51.10	51. 9
150 day season				
Average fixed processing cost[f]	0. 3	0. 2	0. 1	0. 0
Average assembly cost[g]	0.10	0.10	0.10	1. 0
Average total cost	51. 8	51. 7	51. 6	51. 7
Average revenue[e]	49. 5	49. 5	49. 5	49. 5

a. This is the average daily output minus one standard deviation.
b. This is the average daily output.
c. This is the average daily output plus one standard deviation.
d. This is the maximum output that can be produced in one day if the mortar is constantly used for pounding.
e. This item is from Table 4.2.
f. This item is derived from Table 4.6.
g. This is the cost of transportation by headload.

Table 4.8.-Budgeted average cost for the Okigwi Division hand method processing firms, 1964

Item	Hundredweight of oil produced per eight hour day .01[a]	.10[b]	.20[c]	.70[d]
	---------- s.d ----------			
Average variable processing cost[e]	58. 1	58. 1	58. 1	58. 1
50 day season				
Average fixed processing cost[f]	8. 0	.10	0. 5	0. 1
Average assembly cost[g]	4.10	1. 0	1. 0	1. 1
Average total cost	70.11	59.11	59. 6	59. 3
150 day season				
Average fixed processing cost[f]	2. 8	0. 3	0. 2	0. 0
Average assembly cost[g]	2. 0	0. 9	0.10	1. 0
Average total cost	62. 9	59. 1	59. 1	59. 1
Average revenue	42. 9	42. 9	42. 9	42. 9

a. This is the average daily output minus one standard deviation.
b. This is the average daily output.
c. This is the average daily output plus one standard deviation.
d. This is the maximum output that can be produced in one day if the mortar is constantly used for pounding.
e. This item is from Table 4.3.
f. This item is derived from Table 4.6.
g. This is the cost of transportation by headload.

Summary

The hand method of processing is conducted by the family members of a household who share in the returns for producing, processing, and marketing palm products. The firms sampled in Abak and Okigwi Divisions produced an average of .30 and .10 hundredweight of oil per day, respectively, and operated an average of 31 and 40 days per annum, respectively. At the average level of firm output in Abak Division it cost 51s 11d to produce one hundredweight of oil, and in Okigwi Division it cost 59s 11d if firms were operated for 50 days per annum. There are only small changes from this average as the length of season and quantity of output per day are varied because at least 96 per cent of the average total cost is variable cost.

CHAPTER V

THE SCREW PRESS PROCESSING TECHNOLOGY

Introduction

The introduction of the screw press in Nigeria.--During the decade from 1920 to 1930 personnel in the Nigerian Department of Agriculture tested several mechanical methods for extracting oil from palm fruit. In 1932 they selected the Duchscher press, designed and built by Messrs. Duchscher and Cie of Luxembourg, as the most economical mechanical method for processing palm fruit.[1] When it was introduced in Nigeria, the 22 gallon size Duchscher press sold for £13 and the nine gallon size sold for £8.[2] To stimulate the sale of these mechanical presses they were demonstrated to farmers at prominent locations in the Region.[3] For example, demonstrations of the hand method and the screw press were conducted at Ikparakwa, Abak, Etinan, and Nung Udoe, in Eastern Nigeria.[4] Farmers became acquainted with the characteristics

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[1]Forde and Scott, op. cit., p. 237.

[2]D. Manlove and W. A. Watson, Press Extraction of Palm Oil in Nigeria, Nigerian Agricultural Department Bulletin No. 10, (Lagos: Government Printer, 1st Aug. 1931), p. 33.

[3]Memorandum of the Agricultural Superintendent Umuahia to the District Officer Uyo, 10 May 1932, in Uyo Province Papers (Eastern Nigeria Archives, Enugu).

[4]Letter of the Resident Calabar Province to the District Officer Uyo, 28 March 1934, in Uyo Province Papers (Eastern Nigeria Archives, Enugu).

of the Duchscher press when their fruit was processed without charge at these demonstrations. Over the past three and one-half decades the screw type oil press has become a widely used method for oil extraction in Nigeria. By the end of 1938 farmers in Nigeria had purchased 834 presses.[5] In 1953 it was estimated that 9,000 presses were being used in Nigeria.[6] In March 1964, approximately 17,664 screw presses were operating in the palm belt of Eastern Nigeria.[7] Today these presses are manufactured and repaired at blacksmith shops throughout the palm belt.[8]

Description of the screw press.--The framework of the screw press consists of a flat horizontal metal base, a vertical threaded shaft attached securely to the center of the base, a cylindrically shaped wooden lath press cage, and an internally threaded block with a ram plate attached beneath it. To press palm fruit the internally threaded block is placed on the vertical threaded shaft; two iron pipes are placed horizontally in holes drilled in the threaded block; two men hold the pipes and walk around the press. As they walk, the threaded block screws down the vertical shaft

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[5] Forde and Scott, loc. cit.

[6] S. C. Nwanze, Processing Agricultural Produce: Palm Oil, A Report to the United Nations Conference on the Application of Science and Technology for the Benefit of Less Developed Areas, (New York: The Conference, Sept. 27, 1962), p. 3.

[7] This estimate assumes that the ratio of the number of screw presses in the two divisions surveyed to the number of screw presses in the palm belt is the same as the ratio of the population in the two divisions studied to the population in the palm belt i.e., 1:8.

[8] In 1964 the screw presses with small press cages sold for approximately £15, and those with the largest press cages sold for approximately £40.

pressing the fruit between the ram plate, the press cage walls and the base. The oil is expelled through one-eighth inch spaces between the vertical wooden laths of the press cage, flows through a hole in the base, and is collected in a kerosene tin beneath the press. Although the size of press cages surveyed ranged from 13 inches in diameter and 15 inches in height to 24 inches in diameter and 24 inches in height, the average size was 18.2 inches, in diameter, 22.8 inches in height. This size press has a capacity of 4811 cubic inches which holds about 233 pounds of pounded palm fruit.

Description of the processing operation.--The screw press method of processing is conducted in five distinct stages in both divisions surveyed i.e., sterilization, pounding, first pressing, separation, and second pressing.[9] (Stage one - sterilization) Palm fruit is placed in a four hundredweight metal container constructed by cutting an eight hundredweight oil drum in half. The drum of fruit with some water added is heated over an open fire to sterilize the fruit. Jute bags are often used to cover the open top of the drum so steam will not escape during sterilization. (Stage two - pounding) After the fruit is sterilized with steam, it is placed in another similarly constructed four hundredweight container that is used for a mortar. Several people gather around this container and pound the fruit with wooden pestles. (Stage three - first pressing) After the fruit is pounded, it is placed in the screw press where the oil is squeezed from the pounded fibre and nut mixture.

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[9]The fuel used to heat the fruit is primarily a by-product of the processing operation. The fibre and shells from the processing operation are sometimes supplemented by palm fronds and wood as sources of fuel.

(Stage four - separation) The fibre and nut mixture is removed from the press and spread upon the ground so women and children can separate fibre from the nuts by hand. (Stage five - second pressing) In the first pressing the nuts often touch each other forming protective pockets where the fibre is subjected to little pressure. To extract the oil that remains in the fibre, it is pressed a second time in the screw press after it has been separated from the nuts.

The Sample Studied

The screw press firms described here were selected in the same location in the same manner as the samples of hand method firms described in the previous chapter. Refer to page 36 of Chapter IV for a detailed description of the geographical area, the method of sample selection, and the method of data collection.

Description of the Firms Surveyed

Characteristics of firm operations.--Although most screw press firms purchase fruit, process it, and sell the oil and nuts, some provide a custom processing service on a fee basis for fruit owners in the local area. In Abak Division, the 21 firms sampled from the total population of 706 firms worked an average of 60 per annum and produced an average of one hundredweight of oil per day. Eight per cent of the firms in Abak sold all the oil they produced; four per cent consumed all of it in their own homes; 88 per cent used the oil produced partly for home consumption and partly for sale. In Okigwi Division, the 26 firms sampled from the total population of 1520 firms operated an average of 94 days each year and produced an average of two hundredweight of oil per day. In Okigwi 80 per cent of the firms interviewed sold all of the oil they produced; none of the firms consumed it only; 20 per cent of them consumed part of it and sold the remaining portion.

Description of labor inputs.--Although processing by the screw press employs more men than by the hand method, the largest proportion of the labor inputs are provided by women and children. In Abak Division an average of 3.5 woman day equivalents and .8 man days are required to produce one hundredweight of oil (see Table 5.1).

Table 5.1.-Average labor inputs for screw press processing firms in Abak and Okigwi Divisions, 1964

Stage of Operation	Average labor inputs per hundredweight of oil: Abak Division		Okigwi Division	
	Woman day equivalents[a]	Man days[b]	Woman day equivalents[a]	Man days[b]
Sterilization	1.4	--	.4	.2
Pounding	.4	.4	.4	.3
First pressing	.2	.3	--	.2
Separation	1.4	--	1.6	--
Second pressing	.1	.1	--	.1
Total	3.5	.8	2.4	.8

a. One woman day equivalent equals eight woman hours or 32 child hours.

b. One man day equals eight man hours.

In Okigwi Division an average of 2.4 woman day equivalents and .8 man days are used to produce one hundredweight of oil. In both Divisions men most frequently assist in the physically demanding tasks of pounding and pressing while women and children sterilize the fruit and separate the nuts from the fibre. Since most workers were members of the family they were not paid wages for their labor.

Budgeted Costs and Revenue

Average variable processing cost and average revenue.--In Abak Division, the average variable processing cost is 47s 4d and the average revenue is 48s 11d per hundredweight of oil (see Table 5.2).

Table 5.2.-Components of average variable processing cost and average revenue for screw press processing firms in Abak Division, 1964

Item	Quantity per cwt. of oil produced[a]	Price of item per unit	Value per cwt. of oil produced
		s. d.	s. d.
Fruit	6.1 cwt.	6. 6 per cwt.[b]	39. 8
Labor	3.5 woman day equivalents[c]	1. 6 per day[d]	5. 3
Labor	.8 man days[e]	3. 0 per day[d]	2. 5
Average variable processing cost			47. 4
Oil	1.0 cwt.	33.11 per cwt.[a]	33.11
Nuts	4.0 cwt.	3. 9 per cwt.[f]	15. 0
Average revenue			48.11

a. Each of these items is the average for the firms surveyed.
b. Standard fruit prices are used for each of three locations, i.e., 6s 6d in Abak Division, 6s 3d in Eastern Nigeria, and 6s 0d in Okigwi Division.
c. One woman day equivalent equals eight woman hours or 32 child hours.
d. These standard unskilled labor prices are applied for all technologies operating anywhere in Eastern Nigeria.
e. One man day equals eight hours.
f. Standard nut prices are used in each of three locations, i.e., 3s 7d in Okigwi Division, 3s 8d in Eastern Nigeria, and 3s 9d in Abak Division.

In Okigwi Division, the average variable processing cost is 48s 0d and the average revenue is 45s 6d per hundredweight of oil (see Table 5.3). Since the budgeted average variable processing cost is higher than the average revenue for screw press operations in Okigwi, it appears that family labor working in some of the Okigwi firms may receive a lower daily return than the standard wage of 3s per day for men and 1s 6d per day for women which are used in these budgets.

Table 5.3.-Components of average variable processing cost and average revenue for screw press processing firms in Okigwi Division, 1964

Item	Quantity per cwt. of oil produced[a]	Price of item per unit	Value per cwt. of oil produced
		s.d	
Fruit	7.0 cwt.	6. 0 per cwt.[b]	42. 0
Labor	2.4 woman day equivalents[c]	1. 6 per day[d]	3. 7
Labor	.8 man days[e]	3. 0 per day[d]	2. 5
Average variable processing cost			48. 0
Oil	1.0 cwt.	30.10 per cwt.[a]	30.10
Nuts	4.1 cwt.	3. 7 per cwt.[f]	14. 8
Average revenue			45. 6

a. Each of these items is the average for the firms surveyed.
b. Standard fruit prices are used for each of three locations, i.e., 6s 6d in Abak Division, 6s 3d in Eastern Nigeria, and 6s 0d in Okigwi Division.
c. One woman day equivalent equals eight woman hours or 32 child hours.
d. These standard unskilled labor prices are applied for all technologies operating anywhere in Eastern Nigeria.
e. One man day equals eight hours.
f. Standard nut prices are used in each of three locations, i.e., 3s 7d in Okigwi Division, 3s 8d in Eastern Nigeria, and 3s 9d in Abak Division.

<u>Annual fixed processing cost</u>.--The equipment requirements and cost listed in Tables 5.4 and 5.5 are derived in the same manner as those for the hand method of processing (see pages 41 and 42).

Table 5.4-Equipment requirements and equipment cost for the Abak Division screw press processing firms, 1964

Item	Number required	Estimated life	Replacement cost	Total investment	Annual depreciation[a]
		years	£.s.d		
Screw press	1	10	27. 6. 0	27. 6. 0	2.14. 7
Building	1	5	4. 4. 4	4. 4. 4	0.16. 9
Metal mortar	1	1	1. 9. 4	1. 9. 4	1. 9. 4
Metal sterilization drum	1	3	1. 9. 4	1. 9. 4	0. 9. 9
Pounding stick	2	1	0. 0. 6	0. 1. 0	0. 1. 0
Kerosene tin	2	2	0. 2. 6	0. 5. 0	0. 2. 0
Round basket	3	1	0. 1. 2	0. 3. 6	0. 7. 0
Shovel	1	4	0. 9. 3	0. 9. 3	0. 2. 4
Total				35. 7. 9	6. 2. 6

a. Straight line depreciation method i.e. total investment divided by estimated life.

The total investment in equipment is £35. 7. 9 in Abak Division and £35.16. 7 in Okigwi Division. When each item of equipment is depreciated by assuming a constant annual depreciation over the estimated life, the annual fixed cost for depreciation is £6. 2. 6 in Abak Division and £6. 6.10 in Okigwi Division. The total annual fixed cost which is composed of the depreciation on equipment, and interest

Table 5.5.-Equipment requirements and equipment cost for the Okigwi Division screw press processing firms, 1964

Item	Number required	Estimated life	Replacement cost of each	Total investment	Annual depreciation[a]
		years	£.s.d		
Screw press	1	10	27. 6. 0	27. 6. 0	2.14. 7
Building	1	5	4. 4. 4	4. 4. 4	0.16. 9
Metal Mortar	1	1	1. 9. 4	1. 9. 4	1. 9. 4
Metal sterilization drum	1	3	1. 9. 4	1. 9. 4	0. 9. 9
Pounding stick	2	1	0. 0. 8	0. 1. 4	0. 1. 4
Kerosene tin	2	2	0. 3.11	0. 7.10	0. 3.11
Round basket	3	1	0. 2.11	0. 8. 9	0. 8. 9
Rectangular basket	1	4	0. 9. 8	0. 9. 8	0. 2. 5
Total				35.16. 7	6. 6.10

a. Straight line depreciation method i.e. total investment divided by estimated life.

on investment is £7. 7. 0 in Abak and £7.11.11 in Okigwi (see Table 5.6).

Average total processing cost.--The average total processing cost is 51s 7d in Abak Division at the average level of firm output per day for a 50 day season (see Table 5.7). In Okigwi Division the average total processing cost is 50s 11d for a season of 50 days at the average level of firm output (see Table 5.8). The budgets in both tables have similar cost patterns. Since average variable processing cost is the major component of average total cost, only a slight reduction in average total cost occurs when the quantity

Table 5.6.-Annual fixed and general cost for screw press processing firms in Abak and Okigwi Divisions, 1964

Item	Abak Division	Okigwi Division
	£.s.d	
Depreciation on equipment[a]	6. 2. 6	6. 6.10
Interest on investment[b]	1. 4. 6	1. 5. 1
Total annual fixed cost	7. 7. 0	7.11.11
Repairs[c]	0.17. 8	0.17.11
Total annual general cost	0.17. 8	0.17.11

a. This item is derived from Tables 5.4 and 5.5.
b. This item is seven per cent of one-half the initial investment capital equipment enumerated in Tables 5.4 and 5.5.
c. This item is 2.5 per cent of the total investment enumerated in Tables 5.4 and 5.5.

processed per day or the length of season is increased if the minimum level of output is excluded. In Abak Division, the average total cost declines from 51s 7d for a 50 day season at an output of 1.0 hundredweight to 49s 0d during a 150 day season at an output of 4.0 hundredweight. The average total cost in Okigwi is reduced from 50s 11d to 49s 9d per hundredweight when the length of season is increased from 50 to 150 days and the quantity of oil processed each day is increased from 2.0 hundredweight to 6.4 hundredweight. This cost pattern for screw press firms is quite similar to the one that occurs in the hand method operations discussed in Chapter IV.

Table 5.7.-Budgeted average cost for the Abak Division screw press processing firms, 1964

Item	Hundredweight of oil produced per eight hour day			
	0.1[a]	1.0[b]	2.0[c]	4.0[d]
	s.d			
Average variable processing cost[e]	47. 4	47. 4	47. 4	47. 4
50 day season				
Average general processing cost[f]	3. 6	0. 4	0. 2	0. 1
Average fixed processing cost[f]	29. 5	2.11	1. 6	0. 9
Average assembly cost[g]	1. 3	1. 0	1. 2	1. 5
Average total cost	81. 6	51. 7	50. 2	49. 7
150 day season				
Average general processing cost[f]	1. 2	0. 1	0. 1	0. 0
Average fixed processing cost[f]	9.10	1. 0	0. 6	0. 3
Average assembly cost[g]	1. 0	1. 0	1. 1	1. 5
Average total cost	59. 4	49. 5	49. 0	49. 0
Average revenue	48.11	48.11	48.11	48.11

a. This is the average daily output minus one standard deviation.
b. This is the average daily output of the 20 firms analyzed.
c. This is the average daily output plus one standard deviation.
d. This maximum daily output assumes fruit is constantly being pressed by the average unskilled laborers employed in their usual manner of operation.
e. This item is from Table 5.2.
f. This item is derived from Table 5.6.
g. This is the cost of transportation by headload.

Table 5.8.-Budgeted average cost for the Okigwi Division screw press processing firms, 1964

Item	Hundredweight of oil produced per eight hour day 0.1[a]	2.0[b]	4.0[c]	6.4[d]
	s.d			
Average variable processing cost[e]	48. 0	48. 0	48. 0	48. 0
50 day season				
Average general processing cost[f]	3. 7	0. 2	0. 1	0. 1
Average fixed processing cost[f]	30. 5	1. 6	0. 9	0. 6
Average assembly cost[g]	1. 2	1. 3	1. 6	1. 8
Average total cost	83. 2	50.11	50. 4	50. 3
150 day season				
Average general processing cost[f]	1. 2	0. 1	0. 0	0. 0
Average fixed processing cost[f]	10. 2	0. 6	0. 3	0. 2
Average assembly cost[g]	.11	1. 3	1. 5	1. 7
Average total cost	60. 3	49.10	49. 8	49. 9
Average revenue	45. 6	45. 6	45. 6	45. 6

a. This is the average daily output minus one standard deviation.
b. This is the average daily output of the 20 firms analyzed.
c. This is the average daily output plus one standard deviation.
d. This maximum daily output assumes fruit is constantly being pressed by the average unskilled laborers employed in their usual manner of operation.
e. This item is from Table 5.3.
f. This item is derived from Table 5.6.
g. This is the cost of transportation by headload.

Comparison of Abak and Okigwi Divisions

The average processing firm in Okigwi requires more fruit to yield a given quantity of oil and receives a lower price per unit for oil than the average firm in Abak. The average fruit to oil ratio for the two technologies in Okigwi Division is 6.1, but in Abak Division it is 6.95. The average price per hundredweight for oil in Okigwi Division is 30s, but it is 34s 2d in Abak Division (compare Tables 4.2 and 5.2 with Tables 4.3 and 5.3). These differences are not correlated with the average quantity of output per day because Okigwi screw press firms have a greater average daily output than Abak, but Okigwi hand press firms have a smaller average daily output than Abak.

Fruit to oil ratio.--In Abak Division both screw press and hand method processing technologies require an average of 6.1 hundredweight of fruit to produce a hundredweight of oil. But in Okigwi Division average firms require 7.0 and 6.9 hundredweight of fruit to produce a hundredweight of oil by the screw press and hand method processing technologies, respectively. This difference occurs because the fruit quality is lower in Okigwi Division than in Abak Division. The lower quality fruit in Okigwi is related to the lower annual rainfall and poorer quality soil in that Division.

Oil prices.--The price received for oil is higher in Abak than in Okigwi Division. The screw press and hand method processing technologies receive average prices of 33s 11d and 34s 5d per hundredweight respectively in Abak Division. However, in Okigwi average prices of only 30s 10d and 29s 2d per hundredweight are received for palm oil produced by the screw press and hand method, respectively.

This difference in oil price between Divisions is caused by the higher cost of transporting oil 140 miles from Okigwi to a port of export than the cost of transporting oil 40 miles from Abak to a port of export. At a transport cost of 10d per ton-mile the additional 100 miles of transport from Okigwi to a port of export is 4s 2d per hundredweight of oil which is approximately equal to the difference in oil price between Abak and Okigwi Divisions.[8]

Implications of these differences.--These differences between divisions indicate that processing conditions are not perfectly homogeneous throughout the Eastern Nigerian palm belt. This is important to consider when interpreting and applying the information provided in this thesis. One example illustrating the need for careful interpretation of these data is the meaning attached to the average price received for palm oil by the hydraulic hand press processing firms in Eastern Nigeria. These firms received an average price of 38s 0d per hundredweight for palm oil. However, the variation between divisions described above implies that the average price in Abak would be higher than 38s 0d, possibly 40s 0d, and the average price in Okigwi be lower than 38s 0d, possibly 36s 0d. Therefore, although the average information presented is extremely useful for general comparisons among technologies, it should be used for specific recommendations to a firm only after the appropriate coefficients are adjusted to fit the particular situation under consideration.

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[8] Nigeria, Federal Ministry of Commerce and Industry, op. cit., p. 8.

Summary

The Duchscher screw press processing method has spread throughout Eastern Nigeria since its introduction in 1932. The firms studied produced an average daily output of 1.0 hundredweight of oil in Abak Division and 2.0 hundredweight of oil in Okigwi Division. They operated an average of 60 days and 94 days annually in Abak and Okigwi Divisions, respectively. The average total cost of producing one hundredweight of oil is budgeted to be 51s 7d in Abak Division and 50s 11d in Okigwi Division. The differences between Abak and Okigwi in fruit to oil ratios and fruit prices indicate that processing conditions are not perfectly homogeneous throughout Eastern Nigeria. Therefore, the budgets developed are more appropriate for general comparisons between technologies than for specific recommendations to a particular firm.

CHAPTER VI

THE HYDRAULIC HAND PRESS PROCESSING TECHNOLOGY

Introduction

The introduction of the hydraulic hand press in Nigeria.--The hydraulic hand press was developed during the late 1950's. It is manufactured by Gebr. Stork and Co.'s Apparatenfacriek N. V., Amsterdam, the Netherlands. Mr. S. C. Nwanze of the Nigerian Institute for Oil Palm Research worked in close cooperation with the Stork Co. during the development and testing of this press.[1] He designed ancillary equipment for use with the press to increase the quantity of oil that could be extracted from palm fruit. The hydraulic hand press processing technology which includes both the hydraulic hand press and the ancillary equipment has been adopted for sale in Eastern Nigeria by the Regional Government. The introduction of this processing technology was financed by project 31 of the Development Plan which provided for a total capital outlay of £400,000 for purchasing processing machinery.[2] The Eastern Regional Government purchased 1,000 hydraulic hand presses and brought them to Port Harcourt for storage.[3] The Government attempted to sell

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[1] J. A. Cornelius, "A Recent Development in the Small Scale Extraction of Palm Oil", Tropical Science, Vol. V, No. 1., (1963), pp. 34-39.

[2] Eastern Nigeria, Ministry of Economic Planning, Eastern Nigerian Development Plan, Op. cit., p. 36.

[3] Nigerian Outlook, March 19, 1963, p. 1.

these presses with the ancillary equipment to processors in Eastern Nigeria. Each processing system was initially offered for sale in 1963 for £530. For £530 the buyer received one press, three ancillary barrels, installation charges, and maintenance inspections every three months for five years beginning April 1963. Buyers were required to provide a down payment of £100 and pay the balance of £430 in 12 equal quarterly installments beginning six months after the press was installed.[4] Since only 31 processing systems had been sold and ten had been installed by December 1963, the Government reduced the price to £484, reduced the deposit to £50, and extended the repayment period to four years.[5] When this study of processing operations was initiated in March 1964, 24 processing systems had been installed in Eastern Nigeria.[6]

Description of the hydraulic hand press.--The hydraulic hand press has an exterior frame made from a long metal I-beam shaped in the form of an inverted U. In the top of the inverted U about seven feet above a concrete base, the metal press ram is supported by a heavy spring attached to the frame. Half way between the press ram and the base is a horizontal metal press table. Two perforated metal cylinders for palm fruit slide freely upon this

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[4] Eastern Nigeria, Ministry of Agriculture, Stork Hydraulic Hand Press, Farmers Bulletin No. 5 (Enugu: Ministry of Agriculture, August, 1963), p. 8.

[5] Eastern Nigeria, Ministry of Economic Planning, 1st Progress Report Eastern Nigeria Development Plan 1962-68, Op. cit., p. 27.

[6] The sale price of the press was reduced further to £250 in March, 1965.

table. When these cylinders are filled with fruit, they are pushed along the press table to a position directly underneath the press ram. As the press operator pumps the handle of a small hydraulic pump fastened to the press frame, the metal press ram is forced down upon the fruit squeezing it between the well of the perforated cylinder and the press table. The oil flows out the perforations in the cylinder wall and is collected in a pail beside the press. After the fruit has been pressed a valve on the pump is opened and the supporting spring returns the press ram up to its original position so another cylinder of fruit can be placed beneath it. Each cylinder contains 1958 cubic inches which holds between 80 and 100 pounds of the pounded palm fruit and nut mixture.[7]

Description of the processing system.--Palm fruit is processed by the hydraulic hand press system in six distinct stages. These stages are sterilization, pounding, reheating, pressing, separation, and clarification. (Stage one - sterilization) In this stage, the palm fruit is steamed in a specially constructed metal drum, that holds from 1000 to 1300 pounds of fruit and can be pivoted in a metal frame to pour out the sterilized fruit. (Stage two - pounding) The sterilized fruit is carried by headpan to a wooden, metal, or concrete mortar where it is pounded with pestles by the workers. (stage three - reheating) The pounded fruit is reheated in another large drum to increase the temperature of the oil and reduce its viscosity so the maximum quantity of oil can be

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[7]"Hydraulic Presses", Stork Palmoil-review, Vol. II, No. 3, (July, 1961), p. 6.

extracted during pressing. Although this processing stage is recommended by the Ministry of Agriculture, 60 per cent of the firms studied skipped this stage, discarded the drum, and pressed the fruit immediately after pounding. (Stage four - pressing) The fruit is pressed as described in the preceeding paragraph. (Stage five - separation) After the fruit is pressed the fibre and kernels are knocked out of the performated cylinder with a stick and spread upon the ground where the employees separate the nuts from the fibre. (Stage six - clarification) While the separation stage is in progress the oil is placed in a drum where it is heated, cooled, and decanted to remove sludge, dirt, and foreign matter. After clarification the oil is placed in eight hundredweight drums for shipment to a licensed buying agent.

The Sample Studied

The hydraulic hand press data analyzed in this chapter are derived from a census of 20 of the 23 firms that were in operation in Eastern Nigeria when the field research was intitated. Some of the processing firms had been operating since November, 1963 while others had been operating for only one week prior to the collection of the input and output data. Since the firms had been operating for only an average of four months, the cost structure of the firms indicated here may be somewhat higher than it will be when the operators gain additional experience with this processing system. The same type of data was collected in the same manner for these firms as for the hand method processing operations which are described in Chapter IV, pages 36 and 37.

Characteristics of firm operations.--These firms purchased fruit from farmers near the plant, employed local laborers in the plant, and sold all the oil in the export market. They produced an average of 2.8 hundredweight of oil per day during an average operating season of 141 days per annum.

Description of labor inputs.--These firms employed a manager and unskilled daily laborers to conduct their processing operations. Most of the laborers were unskilled males, i.e., 2.2 man days per hundredweight of oil produced. The few unskilled women and children employed, 0.4 woman day equivalents per hundredweight of oil produced, separated fibre from the nuts (see Table 6.1). The manager assisted with the processing, supervised the laborers, purchased the fruit, sold the oil, and sold the nuts. At the average daily level of firm output 0.4 man days of the manager's labor can be allocated for each hundredweight of oil produced. When the unskilled and managerial labor are both included, a total of 3.0 man days of labor are used to produce each hundredweight of oil at the average daily level of production.

Budgeted Cost and Revenue

Average variable processing cost and average revenue.--Hydraulic hand press processing systems have an average variable processing cost of 46s 4d and an average revenue of 51s 2d (see Table 6.2). Since fruit costs 39s 2d per hundredweight of oil produced, it is the major part of the average variable processing cost. Although the fruit to oil ratio, 6.3:1, is similar to the fruit to oil ratios for hand method and screw press processing

Table 6.1-Average labor inputs for hydraulic hand press processing firms in Eastern Nigeria, 1964[a]

Stage of Operation	Average labor inputs per hundred-weight of oil produced	
	Woman day equivalents[b]	Man days[c]
Sterilization	-	.5
Pounding	-	.4
Reheating	-	.1
Pressing	-	.6
Separation	.4	.2
Clarification	-	.4
Total	.4	2.2

a. The managerial labor is listed under general costs so this Table is not directly comparable with similar Tables in previous chapters.
b. One woman day equivalent equals eight woman hours or 32 child hours.
c. One man day equals eight man hours.

technologies, the average revenue of the hydraulic press is considerably higher because a higher price, 38s per hundredweight, is received for the hydraulic press oil. This oil has a higher value than oil produced by the screw press or hand method processing technologies because it is clarified during an additional processing stage and collected in a bulk container before it is sold to the licensed buying agent.

Annual fixed and general processing cost.--The equipment requirements for the hydraulic hand press are listed in Table 6.3. The total investment for these firms is £556. 2. 4, and the annual depreciation on this investment is £65. 4. 2. Table 6.4 includes

Table 6.2.-Components of average variable processing cost and average revenue for the hydraulic hand press processing technology in Eastern Nigeria, 1964

Item	Quantity per cwt. of oil produced[a]	Price of item per unit	Value per cwt. of oil produced
		-------------s.d-------------	
Fruit	6.3 cwt.	6. 3 per cwt.[b]	39. 2
Labor	.4 woman day equivalents[c]	1. 6 per day[d]	0. 7
Labor	2.2 man days[e]	3. 0 per day[d]	6. 7
Average variable processing cost			46. 4
Oil	1.0 cwt.	38. 0 per cwt.[a]	38. 0
Nuts	3.6 cwt.	3. 8 per cwt.[f]	13. 2
Average revenue			51. 2

a. Each of these items is the average for the firms surveyed.
b. Standard fruit prices are used for each of three locations, i.e., 6s 6d in Abak Division, 6s 3d in Eastern Nigeria, and 6s 0d in Okigwi Division.
c. One woman day equivalent equals eight woman hours or 32 child hours.
d. These standard unskilled labor prices are applied for all technologies operating anywhere in Eastern Nigeria.
e. One man day equals eight hours.
f. Standard nut prices are used in each of three locations, i.e., 3s 7d in Okigwi Division, 3s 8d in Eastern Nigeria, and 3s 9d in Abak Division.

both the annual fixed and general cost of processing. The fixed cost is £84.13. 5, and the general cost is £28.18. 0 for a 50 day season and £58.18. 0 for a 150 day season. The average fixed cost per hundredweight of oil at the average level of firm output is 12s 1d for a 50 day season and 4s 0d for a 150 day season (see Table 6.5).

Table 6.3.-Equipment requirements and equipment cost for the hydraulic hand press processing firms in Eastern Nigeria, 1964

Item	Number required	Estimated life	Replacement cost of each	Total investment	Annual depreciation[a]
		years	£.s.d		
Press	1	10	459. 8. 4	459. 8. 4	45.18.10
Ancillary equipment- one set of three drums	1	5	24.11. 8	24.11. 8	4.16. 2
Building	1	10	64. 3. 8	64. 3. 8	6. 8. 4
Mortar, metal	2	1	1. 7. 2	2.14. 4	2.14. 4
Shovel	3	1	0.10. 8	1.12. 0	1.12. 0
Basket	6	1	0. 2. 1	1. 5. 0	1. 5. 0
Pail	4	1	0. 8. 1	1.12. 4	1.12. 4
Kerosene tin	4	1	0. 3. 9	0.15. 0	0.15. 0
Total				556. 2. 4	65. 4. 2

a. Straight line depreciation method, i.e., total investment divided by estimated life.

At the average level of firm output the average general processing cost is 4s 1d per hundredweight of oil for a 50 day season and 2s 10d for a 150 day season.

Average total cost.--At the average daily level of output, 2.8 hundredweight, the average total processing cost is 63s 10d during a 50 day season and 54s 5d during a 150 day season (see Table 6.5). Within the range of output considered in these budgets, the average total cost declines from 88s 4d to 51s 5d as the output per day and

Table 6.4-Annual fixed and general cost for hydraulic hand press processing firms in Eastern Nigeria, 1964

Item	50 day season	150 day season
	---------£.s.d--------	
Depreciation on fixed capital investment[a]	65. 4. 2	65. 4. 2
Interest on fixed capital investment[b]	19. 9. 3	19. 9. 3
Total annual fixed cost	84.13. 5	84.13. 5
Repairs[c]	13.18. 0	13.18. 0
Skilled labor[d]	15. 0. 0	45. 0. 0
Total annual general cost	28.18. 0	58.18. 0

a. This item is from Table 6.3.
b. This item is seven per cent of one-half the initial investment in capital equipment listed in Table 6.3.
c. This item is 2.5 per cent of the total investment listed in Table 6.3.
d. This 6s per day for a manager is separated from variable labor cost because it does not change as output per day varies.

the length of season increase. One of the components of average total cost increases and two decline as annual output increases. The 6d increase in average assembly cost is caused by an increase in the length of haul for fruit from .35 mile to .73 mile. The large decline in both average fixed cost and general cost which occurs as more units of output are produced annually offsets the increase in average assembly cost so the average total cost declines.

<u>The implication of cost and revenue for investment and operation</u>.--

Table 6.5.-Budgeted average cost for the Eastern Nigerian hydraulic hand press processing technology, 1964

Item	Hundredweight of oil produced per eight hour day 1.2[a]	2.8[b]	4.4[c]	5.4[d]
	----------s.d----------			
Average variable processing cost[e]	46. 4	46. 4	46. 4	46. 4
50 day season				
Average general processing cost[f]	9. 8	4. 2	2. 8	2. 2
Average fixed processing cost[f]	28. 3	12. 1	7. 8	6. 3
Average assembly cost[g]	1. 0	1. 3	1. 5	1. 6
Average total cost	88. 3	63.10	58. 1	56. 3
150 day season				
Average general processing cost[f]	6. 6	2.10	1.10	1. 6
Average fixed processing cost[f]	9. 5	4. 0	2. 7	2. 1
Average assembly cost[g]	1. 0	1. 3	1. 5	1. 6
Average total cost	63. 3	54. 5	52. 2	51. 5
Average revenue[e]	51. 2	51. 2	51. 2	51. 2

a. This is the average daily output minus one standard diviation.
b. This is the average daily output of the 20 firms analyzed.
c. This is the average daily output plus one standard deviation.
d. This maximum daily output assumes fruit is constantly being pressed by the average unskilled laborers employed in their usual manner of operation.
e. This item is from Table 6.2.
f. This item is derived from Table 6.4.
g. This is the cost of transportation by headload.

The average revenue is less than average total cost at all levels of output per day and lengths of season considered above. This implies that the hydraulic hand press processing system is not an economical investment for an entrepreneur under the conditions outlined here in 1964. But if he has already made the investment, under what cost conditions should he continue operation? A firm should continue in operation if average total cost minus average fixed cost is less than average revenue. As long as this inequality holds, losses are minimized by continuing production. Firms operating under the cost and revenue conditions budgeted in Table 6.5 should continue operating at all levels of output except at a daily output of 1.2 hundredweight or less of oil for either length of season and at a daily output of 2.8 hundredweight or less of oil for a 50 day season. At these three levels of output losses would be minimized by ceasing processing operations. The stability of these conclusions when technical coefficients and prices vary is examined in detail in Chapter IX.

Summary

The hydraulic hand press processing system was developed through the cooperative work of the Nigerian Institute for Oil Palm Research and The Gebr. Stork Company. Its introduction in Eastern Nigeria was financed by the Regional Government during the 1962-68 Development Plan. This processing system is a six stage operation consisting of sterilization, pounding, reheating, pressing, separation, and clarification. Date about firm operations were secured through a detailed analysis of 20 of the 23 firms operating in Eastern

Nigeria when the field work for this study was conducted. These firms produce an average of 2.8 hundredweight of oil per day during an average operating season of 141 days per annum. They employ primarily male laborers who produce one hundredweight of oil with an average labor input of 3.0 man days. The firms produce one hundredweight of oil from an average fruit input of 6.3 hundredweight. The budgets of cost and revenue indicate average total cost declines from 88s 4d to 51s 5d as the output per day and length of season increase. They show this processing system is an uneconomical investment because the average revenue of 51s 2d is less than average total cost for all levels of output considered. However, firms already operating under the conditions specified for five of the eight levels of output budgeted should continue processing. At these five levels of output losses are minimized by continuing production because the average total cost minus average fixed cost is less than average revenue.

CHAPTER VII

THE PIONEER OIL MILL PROCESSING TECHNOLOGY

Introduction

The introduction of the pioneer oil mill in Nigeria.--A pioneer oil mill factory was designed and tested by the United Africa Company in 1937. Four of these mills were installed on United Africa Company plantations in Nigeria where they were tested for several years. The first pioneer oil mills that relied upon small farmers as a source of fruit rather than plantations was installed at Amuro, in Okigwi Division,in Eastern Nigeria in 1946.[1] By January, 1949, The Nigerian Government had installed six mills to process fruit harvested by small farmers from their wild palm trees.[2] In 1949 the Eastern Regional Production Development Board became responsible for the introduction of these factories. By 1952, they had purchased and installed more than fifty mills at various locations in the Eastern Region.[3] Many people opposed the installation of these mills since they thought existing patterns of processing and marketing would be

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[1] "Mechanised Milling - I", Nigerian Marketing Board Journal, Vol. I, No. 2, (1952), p. 36.

[2] "Produce Goes to Market", Statistical and Economic Review, No. 3, (March, 1949), p. 7.

[3] "Mechanised Milling - I", loc. cit.

seriously disrupted. Even though there was opposition to the mills in some local areas, the Production Development Board continued to locate new mills in The Region. By 1961, 99 mills had been installed and the responsibility for their operation had been given to the Eastern Nigerian Development Corporation.[4] Since 1961 about 34 of these mills have ceased operation because costs exceeded revenue. About one-half of the mills that were closed by the Eastern Nigerian Development Corporation had been sold to private individuals and communities. The economic failure of some pioneer oil mills has been attributed to numerous factors. Most people attribute mill failure primarily to the siting of mills in areas where the quantity and quality of fruit supplied by the small farmers is low.[5,6,7]

Description of the pioneer oil mill processing system.-- The seven processing stages in a pioneer oil mill factory are fruit sterilization, fruit digestion, oil extraction, oil clarification, fibre and nut separation, nut decortication and shell and kernel separation.[8] (Stage one - fruit sterilization) The fruit is sealed in an autoclave where steam, under a pressure of about 20 pounds

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[4] S. C. Nwanze, "The Economics of the Pioneer Oil Mill", Journal of the West African Institute for Oil Palm Research, Vol. III, No. 11, (April, 1961), p. 233.

[5] Ibid, p. 235-36.

[6] Daily Express, March 20, 1962, p. 1.

[7] W. F. La Lau, Report on the Survey of the Pioneer Oil Mills in the Western Region, (Ibadan: by the author, May 1, 1962), p. 3. (Mimeograph)

[8] W. D. Raymond, op. cit., p. 77.

per square inch, sterilizes it in fifteen to twenty minutes.[9] (Stage two - fruit digestion) After sterilization, the fruit is placed in a cylindrically shaped tank where the pericarp is broken and the oil bearing cells are ruptured by blades attached to a vertical rotating rod. The digestor prepares fruit for oil extraction in the same manner that pounding prepares fruit for pressing in the small scale processing methods previously described. (Stage three - oil extraction) A centrifuge is used to extract oil from the digested fruit mash. When the centrifuge spins the fruit mash at a high speed, oil is forced out of the spinning perforated cylinder and is pumped into large clarification tanks. (Stage four - oil clarification) The oil is allowed to cool in the clarification tanks while dirt and foreign matter settle to the bottom of the tanks. After clarification the oil is drained from the tanks and poured into eight hundredweight drums for shipment to the port. (Stage five - fibre and nut separation) To separate the fibre from the nuts they are tumbled in a horizontal revolving cylinder. The fibre is dislodged from the nuts and expelled through perforations in the cylinder wall while the nuts roll through the cylinder and out the end. Since this processing stage required more man hours of labor than any other stage in the small scale processing methods, its mechanization in the pioneer mill results in a considerable reduction in the labor required to produce a hundredweight of oil. (Stage six - nut decortication) The nuts are cracked mechanically and some of the fine shells

[9]Power for processing is supplied by a steam engine. The fibre and shells which are by-products of the processing operation are used as fuel to heat the steam boiler.

and dirt are separated from the larger shells and kernels. (Stage seven - shell and kernel separation) A mixture which contains the kernels and most of the large pieces of shell is placed in a concrete trough filled with mud. By blending the dirt and water in appropriate proportions, a mixture of mud is obtained with a specific gravity that will enable the kernels to rise to the surface and the shells to settle to the bottom of the trough. The kernels are skimmed off the top with sieves, washed to remove the mud, spread on heated concrete to dry, and packed in jute bags for shipment to the port.

The Sample Studied

These budgets are prepared from secondary data about the 67 pioneer oil mills operated by the Eastern Nigerian Development Corporation. These data are supplemented with information obtained from three private pioneer oil mills operating in Eastern Nigeria.

Description of the Firm Operations

Both public and private pioneer oil mills employ labor in roughly constant proportion to the quantity of fruit they process. It is possible to operate a pioneer oil mill with different numbers of employees because most of the unskilled laborers tasks consist of transporting materials from one processing machine to another. If a plant has a high input of fruit several men can be employed to transfer materials from one machine to another so the machines will be constantly in operation. If a plant has low inputs of fruit, only a few men may be employed, and the machines may be used at much less than their capacity. The public and private mills studied employed men for all stages of the processing operation. The 67 publicly owned pioneer oil mills produced an average of 16.7 hundredweight of oil a day and process 297 days annually.

Average variable processing cost and average revenue.--
The average variable processing cost is 38s 11d per hundredweight of oil produced, and the average revenue is 51s 4d (see Table 7.1).

Table 7.1.-Components of average variable processing cost and average revenue for pioneer oil mills in Eastern Nigeria, 1964

Item	Quantity per cwt. of oil produced[a]	Price of item per unit	Value per cwt. of oil produced
		s.d	s.d
Fruit	5.8 cwt.	6. 3 per cwt.[b]	36. 3
Labor[c]	.9 man days[d]	3. 0 per day[c]	2. 8
Average variable processing cost			38.11
Oil	1.0 cwt.	38. 1[a]	38. 1
Kernels	.6 cwt.	22. 1[a]	13. 3
Average revenue			51. 4

a. Each of these items is the average for the 67 ENDC pioneer oil mills.
b. Standard fruit prices are used for each of three locations, i.e., 6s 6d in Abak Division, 6s 3d in Eastern Nigeria, and 6s 0d in Okigwi Division.
c. The skilled labor is not included here, but is listed under general cost in Table 7.3.
d. One man day equals eight hours.
e. This standard unskilled labor price is applied for all technologies operating anywhere in Eastern Nigeria.

The variable processing cost is composed of the cost of fruit and the cost of labor. The fruit to oil ratio of 5.8:1 for the pioneer oil mills is lower than the fruit to oil ratio of the three technologies previously considered. This means that pioneer oil mills extract more of the available oil in wild palm fruit than the screw press or the hydraulic hand press. When both the skilled and unskilled labor inputs are included, 1.1 man days are utilized to produce one hundredweight of oil. The mechanization of processing in the pioneer oil mills provides a significant reduction in the labor required to produce a unit of oil compared to small scale methods even though the number of processing stages are increased by adding nut decortication and separation. The average revenue of 51s 4d per hundredweight of oil is composed of revenue from oil and kernels. Since pioneer oil mills have machinery to crack palm nuts and separate the broken shells from the kernels, they sell kernels to the marketing board rather than selling the whole nuts to local women.

Annual fixed and general processing cost.--A new pioneer oil mill is valued at £18,000 (see Table 7.2). If the mill is depreciated over a fifteen year life, the annual depreciation is £1200. The annual depreciation is added to the interest on investment to obtain the total annual fixed cost of £1830 (see Table 7.3). The general processing cost is composed of repairs and skilled labor. During 150 day and 250 day seasons the total annual general cost is £750 and £950, respectively.

Average total cost.--The average total cost at the average

Table 7.2 -Capital cost of a fully equipped pioneer oil mill in Eastern Nigeria, 1964[a]

Item	Number required	Estimated life	Replacement cost	Annual depreciation[b]
		years	£	
Mill and building	1	15	18,000	1200

a. S. C. Nwanze, "The Economics of the Pioneer Oil Mill", Journal of the West African Institute for Oil Palm Research, Vol. III, No. 11 (April, 1961), p. 244.
b. Straight line depreciation method, i.e., replacement cost divided by estimated life.

Table 7.3.-Annual fixed and general cost for the pioneer oil mill in Eastern Nigeria, 1964

Item	150 day season	250 day season
	£.s.d	
Depreciation on fixed capital investment[a]	1200. 0. 0	1200. 0. 0
Interest on fixed capital investment[b]	630. 0. 0	630. 0. 0
Total annual fixed cost	1830. 0. 0	1830. 0. 0
Repairs[c]	450. 0. 0	450. 0. 0
Skilled labor[d]	300. 0. 0	500. 0. 0
Total annual general cost	750. 0. 0	950. 0. 0

a. This item is derived from Table 7.2.
b. This item is seven per cent of one-half the initial investment in capital equipment listed in Table 7.2.
c. This item is 2.5 per cent of the total investment in capital listed in Table 7.2.
d. This item includes an engineer @ 15s per day, a clerk @ 10s per day, a fruit buyer @ 9s per day, and a manager @ 6s per day. It is separated from variable labor cost because it does not change as output per day varies.

level of output during an eight hour shift is 61s 5d during a 150 day season and 54s 2d during a 250 day season (see Table 7.4). It declines from a high of 67s 9d to a low of 50s 4d per hundredweight of oil produced as the quantity of output per day and the length of season increase. Average total cost declines because the annual fixed and general processing cost is divided among more units of output as the annual output increases. This decline in fixed and general cost is slightly offset by the increase in average assembly cost of 5d that occurs as the length of haul increases from 1.08 to 1.48 miles. The average total cost exceeds the average revenue at all levels of output budgeted except when 24 hundredweight of oil are processed per day during a 250 day season.

Summary

The pioneer oil mills were introduced in Nigeria through the joint efforts of the United African Company and The Nigerian Government. This processing system has seven stages of operation, i.e., fruit sterilization, fruit digestion, oil extraction, oil clarification, fibre and nut separation, nut decortication, and shell and kernel separation. This method of processing is different from the small scale methods because the oil is extracted by a centrifuge rather than a press and nuts are cracked to obtain the kernels rather than sold to local women for cracking. The 67 government pioneer oil mills processed an average of 16.7 hundredweight of oil a day and operated 297 days per annum. The budgets show that average total cost declines from 67s 9d to 50s 4d per hundredweight of oil produced as the quantity of output per day

Table 7.4.-Budgeted average cost for Eastern Nigerian pioneer oil mill processing technology, 1964

Item	Hundredweight of oil produced per eight hour day			
	12.7[a]	16.7[b]	20.7[c]	24[d]
	s.d			
Average variable processing cost[e]	38.11	38.11	38.11	38.11
150 day season				
Average general processing cost[f]	7.10	6. 0	4.10	4. 2
Average fixed processing cost[f]	19. 3	14. 7	11. 9	10. 2
Average assembly cost[g]	1. 9	1.11	2. 1	2. 2
Average total cost	67. 9	61. 5	57. 7	55. 5
250 day season				
Average general processing cost[f]	6. 0	4. 7	3. 8	3. 2
Average fixed processing cost[f]	11. 6	8. 9	7. 1	6. 1
Average assembly cost[g]	1. 9	1.11	2. 1	2. 2
Average total cost	58. 2	54. 2	51. 9	50. 4
Average revenue[e]	51. 4	51. 4	51. 4	51. 4

a. This is the average output in an eight hour shift minus one standard deviation.
b. This is the average output for the 67 pioneer oil mills during one eight hour shift.
c. This is the average output during an eight hour shift plus one standard deviation.
d. This maximum output for an eight hour shift assumes the autoclave and centrifuge are constantly operated on a 15 minute 30 second cycle.
e. This item is from Table 7.1.
f. This item is derived from Table 7.3
g. This is the cost of transportation by headload.

and the length of season increase. Average total cost exceeds the average revenue of 51s 4d at all levels of output except the capacity level of output during the 250 day season.

CHAPTER VIII

THE STORK MAJOR MILL

Introduction

Introduction in Eastern Nigeria.--Stork palm oil processing machinery built by Gebr. Stork and Co.'s Apparatenfabriek N. V., Amsterdam is used on plantations throughout Africa, Indonesia, Malaysia, South America and Central America.[1] In Nigeria these plants are operating at the Nigerian Institute for Oil Palm Research near Benin, at a private plantation in Calabar Division, and at the Eastern Nigeria Development Corporation's Calaro Oil Palm Estate. In 1963, a Stork major mill to process palm fruit harvested by small farmers from wild palm trees was installed at Owerre Ezukala near Okigwi Division. This plant was installed by a private entrepreneur. The physical input and data presented in this chapter are derived from a case study of this plant.

Description of the processing system.--The plant used as the case study is described below. Since the Stork Company builds palm processing plants from a wide variety of equipment sizes and types, the following description only represents one possible combination of this equipment. The eight stages of the processing cycle are bunch sterilization, fruit and bunch separation, fruit

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[1] "Some References", Stork Palmoil-review, Vol. 1, No. 1, (June, 1960), p. 8.

digestion, oil extraction, oil clarification, nut and fibre separation, nut decortication, and shell and kernel separation. (Stage one - sterilization) The bunches with fruit attached are elevated into a vertical sterilization tank. Steam under pressure sterilizes the two and one-half tons of bunches in a full tank in about 45 minutes. (Stage two - stripping fruit from the bunch) This is the only technology studied where fruit is purchased on the bunch and stripped from the bunch during the processing operation. After sterilization the bunches are placed in the upper end of a long sloping U - shaped trough. This trough is made of metal grating with bars spaced about one and one-half inches apart. As bunches tumble down the trough, metal beater arms, which enter the trough between the grating, strike the bunch knocking the fruit from it. (Stage three - digestion) After the fruit is stripped from the bunch it is elevated into a digestion tank. In this tank the projecting blades on a vertical rotating rod break up the fruit pericarp to prepare it for pressing. (Stage four - oil extraction) The cylindrically shaped press cage holds about 220 pounds of fruit. After it has been filled from the top it is covered and a press ram rises from below to squeeze the oil out of the fruit. (Stage five - oil clarification) The oil is pumped from the press into a clarification tank where the impurities settle from the oil. Then the oil is decanted from the tank into eight hundredweight drums for shipment to the port. (Stage six - nut and fibre separation) As the nuts and fibre tumble in a horizontal rotating cylinder, the fibre is stripped off the nuts and falls through holes in the cylinder wall while the nuts roll out the end of the drum. (Stage seven -

nut decortication) After the nuts are cracked mechanically some of the fine dirt and shells are removed from large shells and kernels. (Stage eight - shell and kernel separation) The shells and kernels are placed in a concrete tank filled with a mixture of clay and water. Differences among the specific gravity of the shells, kernels, and mud cause the kernels to rise to the surface and the shells to settle to the bottom of the mud. Then the kernels are strained from the mud, washed with clear water, dried on concrete floors and bagged for shipment to the port.

Budgeted Cost and Revenue

Average variable processing cost and average revenue.--The average variable processing cost is 29s 8d and the average revenue is 52s 3d (see Table 8.1). This average variable processing cost is composed of the cost of fruit and labor. It is lower than the other technologies studied because the Stork major mill has high technical efficiency in the oil and labor inputs. Since the Stork major mill can extract more of the oil contained in the pericarp only 4.7 hundredweight of wild palm tree fruit is required to produce one hundredweight of oil. At the average daily level of output oil is extracted from the fruit with a total skilled and unskilled labor input of only 0.7 man days per hundredweight of oil produced. This reduction in labor input per unit of output over the pioneer oil mill is even more significant than it appears because the Stork mill labor operates an additional processing stage where the fruit is separated from the bunch.

Annual fixed and general processing cost.--If a one and one-half ton of bunches per hour Stork mill which costs £55209.18. 0, installed in Okigwi Division, is depreciated for a 15 year life, the

Table 8.1.-Components of average variable processing cost and average revenue for a Stork major one and one-half ton mill in Okigwi Division, 1964

Item	Quantity per cwt. of oil produced[a]	Price of item per unit	Value per cwt. of oil produced
		--------------s.d--------------	
Fruit	4.7 cwt.	6. 0 per cwt.[b]	28. 2
Labor[c]	.5 man days[d]	3. 0 per day[e]	1. 6
Average variable processing cost			29. 8
Oil	1.0 cwt.	39. 6 per cwt.[a]	39. 6
Kernels	0.5 cwt.	25. 6 per cwt.[a]	12. 9
Average revenue			52. 3

a. Each of these items was derived from the case study.
b. Standard fruit prices are used for each of three locations, i.e., 6s 6d in Abak Division, 6s 3d in Eastern Nigeria, and 6s 0d in Okigwi Division.
c. The skilled labor is not included here, but is listed under general cost in Table 7.3.
d. One man day equals eight man hours.
e. This standard unskilled labor price is applied for all technologies operating anywhere in Eastern Nigeria.

annual depreciation on the mill is £3680.13. 2 (see Table 8.2).[2] The annual fixed cost which is the sum of the annual depreciation and interest on investment is £5612. 0. 1 for this firm (see Table 8.3). The annual total general cost is £1680. 4.11 and £1880. 4.11 for 150 and 250 day seasons, respectively. It is composed of the cost of repairs and skilled labor.

Average total cost.--At the average level of output during an eight hour day, 22.3 hundredweight of oil, the one and one-half ton Stork mill has average total cost of 60s 1d per hundredweight of

[2]A 15 years depreciation period was used rather than the 10 years recommended by S.C. Nwanze, op. cit., p. 244, because the experience with these plants in Eastern Nigeria indicates the longer depreciation period is a close approximation to the useful life of the plant.

Table 8.2.-Capital cost of a fully equipped Stork major one and one-half ton mill in Okigwi Division, 1964[a]

Item	Number required	Estimated life	Replacement cost	Annual depreciation
		years	£.s.d	
Fully equipped mill	1	15	48984.10. 0	
Building	1	15	6225. 8. 0	
Total			55209.18. 0	3680.13. 2

a. Straight line depreciation method, i.e., replacement cost divided by estimated life.

oil for the 250 day season (see Table 8.4). The average total cost declines from 73s 4d per unit of output to 52s 6d per unit of output as the large annual fixed and general costs are divided by more units of output. At similar levels of output per day the average assembly cost is considerably larger for the Stork major mill than the pioneer oil mill since bunches rather than fruit are transported to the Stork major mill. Since the average revenue is less than average total cost for all levels of firm output budgeted, this firm is operating at a loss. However, at all the levels of output budgeted the average revenue is greater than the difference between average total cost and average fixed cost so the firm can minimize its losses by continuing in operation.

Summary

A case study of a Stork major mill, recently installed in Eastern Nigeria by a private entrepreneur to process wild palm fruit, was used to analyze the operation of this technology. The processing operation

Table 8.3.-Annual fixed and general cost for Stork major one and one-half ton mill in Okigwi Division, 1964

Item	150 day season	250 day season
	----------£.s.d----------	
Depreciation on fixed capital investment[a]	3680.13. 2	3680.13. 2
Interest on fixed capital investment[b]	1932. 6.11	1932. 6.11
Total annual fixed cost	5612. 0. 1	5612. 0. 1
Repairs[c]	1380. 4.11	1380. 4.11
Skilled Labor[d]	300. 0. 0	500. 0. 0
Total annual general cost	1680. 4.11	1880. 4.11

a. This item is derived from Table 8.2.
b. This item is seven per cent of one-half the initial investment in capital equipment listed in Table 8.2.
c. This item is 2.5 per cent of the total investment in capital listed in Table 8.2.
d. This item includes an engineer at 15s per day, a clerk at 10s per day, a fruit buyer at 9s per day, and a manager at 6s per day. It is separated from variable labor cost because it does not change as output per day varies.

consists of eight stages i.e., bunch sterilization, fruit and bunch separation, fruit digestion, oil extraction, oil clarification, nut and fibre separation, nut decortication, and shell and kernel separation. This mill produces an average of 22.3 hundredweight of oil per day. To produce one hundredweight of oil an average of 4.7 hundredweight of fruit and 0.7 man days of labor are required. At the average daily level of firm output, the average total cost is 60s 1d for the 250 day season. Average revenue is lower than average total cost, but it is higher than the difference between average total cost and fixed cost so the firm minimizes its losses by continuing in production.

Table 8.4.-Budgeted average cost for a Stork major one and one-half ton mill in Okigwi Division, 1964

Item	Hundredweight of oil produced per eight hour day 22.3[a]	30.7[b]
	------------------s.d-------------	
Average variable processing cost[c]	29. 8	29. 8
150 day season		
Average general processing cost[d]	10. 1	7. 4
Average fixed processing cost[d]	33. 7	24. 4
Average assembly cost[e]	3. 0	3. 4
Average total cost	73. 4	64. 8
250 day season		
Average general processing cost[d]	6. 9	4.11
Average fixed processing cost[d]	20. 2	14. 7
Average assembly cost[e]	3. 0	3. 4
Average total cost	60. 1	52. 6
Average revenue[c]	52. 3	52. 3

a. This is the average output for an eight hour shift.
b. This maximum output for an eight hour shift assumes the press is operating constantly.
c. This item is from Table 8.1.
d. These items are from Table 8.3.
e. This is the cost of transportation by headload because that was the most economical. However, at 30.7 cwt. per day during a 250 day season transport could be by six-ton lorry since the cost for a lorry equals the cost for headload transport.

CHAPTER IX

COMPARISON OF THE FIVE PROCESSING TECHNOLOGIES

Introduction

This chapter compares five processing technologies on the basis of size, physical input-output ratios, efficiency, composition of total cost, and profitability.

The Comparability and Quality of the Data

It is appropriate to review the similarity and dissimilarity in the quality and reliability of the data collected for each technology before proceeding to compare them. More detailed information about the method of sample selection, the method of data collection, and the size of the sample in relation to the size of the population can be found in the first sections of each chapter. For example, the method used to randomly select a sample of 34 hand method processing firms in Abak Division out of the total population of 14,280 firms is described on pages 36 and 37 in Chapter III. The review of the quality of data presented here should assist the reader in qualifying and weighting the comparisons and recommendations indicated in this chapter and in the following one.

The data for all technologies have the following similar characteristics. The information for each technology is based upon a cross-sectional analysis of many firms representing a wide range of operating conditions. Therefore the data reflect the differences in managerial ability of a great number of Nigerian entrepreneurs. By avoiding the perfections inherent in a laboratory analysis, it is hoped to enhance the practical usefulness of this information for predicting what would occur in the palm belt if changes were made in processing equipment. The data for all technologies were collected during the same season to avoid differences in the oil content of the fruit that might occur under different annual climatic conditions. All data are based upon the wild palm fruit raised throughout the region. When the new hybrid trees developed by the Nigerian Institute for Oil Palm Research become a significant part of the total oil bearing trees harvested, new research on the processing technologies will be needed.

The data collected are dissimilar among technologies in the following characteristics. The hand method and the screw press processing technologies are described by small samples of firms in relation to the large number of firms operating throughout the region. The hydraulic hand press and pioneer oil mill processing technologies are described by small samples which are almost complete censuses of the firms using these methods of processing in Eastern Nigeria. The Stork major mill is a case study of the only firm processing wild palm fruit by this technology in Nigeria. Data from all technologies except the case study exhibited high variability. The high variability in the oil output per day was illustrated in each chapter where the average level of output and the average level plus and minus one standard deviation were used to illustrate the cost and revenue functions. Similarly high variability is characteristic of the fruit and labor inputs per unit of oil output. The differences between technologies indicated in Chapter IX and Chapter X are not statistically significant at the usual levels of reliability specified, e.g., 1 percent or 5 percent. Therefore, the differences and similarities indicated are based primarily upon the stability of the relationships when parameters are changed and the magnitude of the differences between efficiency ratios. Using these criteria brings an element of judgment into the analysis which must be carefully considered when interpreting the conclusions.

Size of Operation and Physical Input-Output Ratios

To aid in comparing these five processing technologies, selected data about the size of operation and the physical inputs discussed in the preceding five chapters are summarized in Table 9.1. These data describe in quantitative terms the trends that occur as capital investment in processing equipment increases. The technologies requiring larger capital investments produce more oil per day and operate more days per year. While the Okigwi and Abak hand method processing technologies produce an average of .20 hundredweight of oil per day during a 35 day season, the Stork major mill produces 22.3 hundredweight of oil per day during a 300 day season. As the capital investment increases, smaller quantities of labor and fruit are required to produce one hundredweight of oil. The quantity of fruit required to produce one hundredweight of oil declines from an average of 6.5 hundredweight for the hand method to 4.7 hundredweight for the Stork major mill. The quantity of unskilled and skilled labor required to produce one hundredweight of oil declines from an average of 9.2 woman day equivalents for the hand method to 0.7 man days for the Stork mill.

Efficiency

<u>The relation of efficiency to cost and revenue</u>.--Efficiency is

Table 9.1.-Size of operation and physical inputs for five processing technologies in Eastern Nigeria, 1964

Technology	Capital investment	Average output per day	Average length of season	Fruit per.cwt. of oil	Labor[a] days per cwt. of oil	Per cent[b] of capacity
	-£.s.d-	cwt. of oil	days	cwt.	days	per cent
Okigwi hand method	0.16.10	0.1	40	6.9	11.1	14
Average hand method		0.2	35	6.5	9.2	
Abak hand method	1.19. 8	0.3	31	6.1	7.3	33
Abak screw press	35. 7. 9	1.0	60	6.1	4.3	25
Average screw press		1.5	77	6.5	3.8	
Okigwi screw press	35.16. 7	2.0	94	7.0	3.2	31
Hydraulic hand press	556. 2. 4	2.8	141	6.3	3.0	51
Pioneer oil mill	18000. 0. 0	16.7	297	5.8	1.1	70
Stork major mill	55209.18. 0	22.3	300	4.7	0.7	69

a. This includes all labor for an eight hour day including both unskilled and skilled labor at the average daily level of output. One man day equals eight man hours or one woman day equivalent. One woman day equivalent equals eight woman hours or 32 child hours.

b. The daily capacity divided by the average daily output.

defined as the value of output divided by the value of inputs. When each unit of output has a constant value, the average total cost per unit of output is a guide to efficiency.[1] However, a brief review of the average revenue for these five processing technologies shows that each unit of output does not have a constant value. This difference among the average revenue occurs for a variety of reasons, such as, differences in the form and quality of the product. Since average revenue is not constant among technologies, it is necessary to consider both the average total cost and the average revenue to compare the efficiency of these technologies. In the following paragraphs an index, constructed by dividing average revenue by the average total cost and then multiplying this quotient by 100, is used to compare efficiency among the five technologies.

The relative efficiency of five processing technologies.--The primary objective of this study is to determine the more efficient processing technologies. The level of efficiency is similar among the screw press, the hydraulic hand press and the pioneer oil mill processing technologies under a wide range of conditions. Since these three technologies involve different scales of operation, they fit closely Stigler's description of industrial conditions. "Actually, we find that in most industries firms

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[1]The term efficiency has different meanings in different contexts. It can mean the physical relation between output and input or monetary relationship between the value of output and the value of input. In a broader sense it may simply refer to the effective operation of an economy in which resources are used appropriately to yield high levels of output.

In this thesis it means the ratio between the value of output and the value of input for some specific palm processing technology. In this chapter it is called efficiency while in the next chapter it is prefaced by the word monetary to insure there is no confusion between its meaning and any broader definition of the term.

of very different sizes survive, and we may infer that commonly there is no large advantage or disadvantage to size over a very considerable range of outputs."[1] In Table 9.2 the five processing technologies are compared for two different sets of seasonal conditions. Under both sets of seasonal conditions, the index of efficiency is relatively constant for the screw press, hydraulic hand press and pioneer oil mill processing technologies. In the first comparison, the efficiency index is an average of 92 for the screw press technologies, 94 for the hydraulic hand press, and 95 for the pioneer oil mill. The hand method firms have an average index level of 83 while the Stork mill has an index level of 87. A similar pattern emerges in the second comparison where the technologies are compared during a 150 day season. Here the screw press, hydraulic hand press and pioneer oil mill have efficiency indexes of 93, 94, and 90, respectively. During the 150 day season, the hand method technologies have an average index level of 84 and the Stork mill has an index level of 71. The index remains relatively constant for either set of seasonal conditions while the average output per day increases from an average of 1.5 hundredweight of oil for the screw press processing technologies to 17.3 hundredweight of oil for the pioneer oil mill. Conversely, for the technologies with outputs per day of 0.2 and 22.3, the efficiency of production appears to be lower.

The importance of considering the efficiency index rather than the average total cost is apparent when they are compared in Table 9.2.

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[1]George J. Stigler, The Theory of Price, (New York: The MacMilliam Company, 1961) p. 144.

Table 9.2.-The relative efficiency of five processing technologies in Eastern Nigeria, 1964

Technology	Average revenue	Approximation of average season for each technology[a]: Average total cost	Approximation of average season for each technology[a]: Efficiency index	150 day season for all technologies: Average total cost[b]	150 day season for all technologies: Efficiency index
	----------s.d----------		Percent	--s.d--	Percent
Okigwi	42. 9	59.11	71	59. 1	73
Average hand method			83		84
Abak hand method	49. 5	51.11	95	51. 7	96
Abak screw press	48.11	51. 7	95	49. 5	97
Average screw press			92		93
Okigwi screw press	45. 6	50.11	89	49.10	89
Hydraulic hand press	51. 6	54. 5	94	54. 5	94
Pioneer oil mill	51. 4	54. 2	95	61. 5	90
Stork major mill	52. 3	60. 1	87	73. 4	71

a. This is 50 days for the hand method and screw press, 150 days for the hydraulic hand press, and 250 days for the pioneer oil mill and the Stork mill.

b. The average total cost is for the average daily level of output of each technology.

In this table, the average total cost alone indicates the screw press processing technology is the most efficient processing method for both sets of lengths of season compared; however, when the value of the output is considered also the three technologies have quite similar levels of efficiency.

Budgets testing constant efficiency.--Several budgets were developed to test the stability of the conclusion that the screw press, hydraulic hand press, and pioneer oil mill technologies have similar levels of efficiency (see Table 9.3 and 9.4). These budgets indicate that for either an increase or decrease in the price of fruit of 6d or 1s the three processing technologies stay within an index number range of four. If the wage rate is decreased 50 per cent the three processing technologies still stay within an index number range of four. None of these changes in the budgets alter the conclusion previously reached that the screw press, hydraulic hand press and pioneer oil mill have similar levels of efficiency. However, a wage increase of 50 per cent, increasing the output per day to plant capacity, and doubling the estimated life of the equipment improves the relative position of the large scale processing methods, i.e., the pioneer oil mill and the Stork major mill.

Changes in the magnitude of the components of average total cost.--There are major changes in the magnitude of the components of average total cost as the size of plant increases. Table 9.5 illustrates the decline in average variable processing cost from 58s 1d to 29s 8d as fixed factors are substituted for variable factors of production in the larger plants. For all of the technologies illustrated in

Table 9.3.-Efficiency indexes for alternative input prices for five processing technologies in Eastern Nigeria, 1964[a]

Technology	Present situation	Fruit price increase		Fruit price constant		Fruit price decrease	
		1s	6d	Wages Increased 50 per cent	Wages decreased 50 per cent	6d	1s
Okigwi hand method	71	64	68	63	82	76	81
Average hand method	83	75	79	75	94	88	94
Abak hand method	95	85	90	86	106	101	107
Abak screw press	95	85	89	88	103	101	108
Average screw press	92	82	86	86	99	98	105
Okigwi screw press	89	78	83	84	95	96	103
Hydraulic hand press	94	84	89	89	101	100	107
Pioneer oil mill	95	86	90	92	97	100	106
Stork major mill	87	80	84	86	88	90	94

a. These indexes are based on the average daily output during the lengths of season indicated in columns two and three of Table 9.2.

Table 9.4.-Efficiency indexes for capacity levels of output and doubled estimated plant life for five processing technologies in Eastern Nigeria, 1964.

Technology	Operation at capacity[a]	Doubled estimated plant life[b]
Okigwi hand method	72	71
Average hand method	83	83
Abak hand method	96	95
Abak screw press	99	96
Average screw press	94	93
Okigwi screw press	91	90
Hydraulic hand press	100	96
Pioneer oil mill	102	100
Stork major mill	100	98

a. This index is based on the capacity level of output per day during the lengths of season indicated in columns two and three of Table 9.2.

b. This index is based on the average daily output during the lengths of season indicated in columns two and three of Table 9.2.

Table 9.5 except the Stork mill, the average variable processing cost is the major portion of average total cost. While the average variable cost declines the average general processing cost increases from zero to 10s 1d, the average assembly cost increases from 0s 9d to 3s 0d, and the average fixed processing cost increases from 0s 3d to 33s 7d.

CHAPTER VIII

THE STORK MAJOR MILL

Introduction

Introduction in Eastern Nigeria.--Stork palm oil processing machinery built by Gebr. Stork and Co.'s Apparatenfabriek N. V., Amsterdam is used on plantations throughout Africa, Indonesia, Malaysia, South America and Central America.[1] In Nigeria these plants are operating at the Nigerian Institute for Oil Palm Research near Benin, at a private plantation in Calabar Division, and at the Eastern Nigeria Development Corporation's Calaro Oil Palm Estate. In 1963, a Stork major mill to process palm fruit harvested by small farmers from wild palm trees was installed at Owerre Ezukala near Okigwi Division. This plant was installed by a private entrepreneur. The physical input and data presented in this chapter are derived from a case study of this plant.

Description of the processing system.--The plant used as the case study is described below. Since the Stork Company builds palm processing plants from a wide variety of equipment sizes and types, the following description only represents one possible combination of this equipment. The eight stages of the processing cycle are bunch sterilization, fruit and bunch separation, fruit

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[1] "Some References", Stork Palmoil-review, Vol. 1, No. 1, (June, 1960), p. 8.

digestion, oil extraction, oil clarification, nut and fibre separation, nut decortication, and shell and kernel separation. (Stage one - sterilization) The bunches with fruit attached are elevated into a vertical sterilization tank. Steam under pressure sterilizes the two and one-half tons of bunches in a full tank in about 45 minutes. (Stage two - stripping fruit from the bunch) This is the only technology studied where fruit is purchased on the bunch and stripped from the bunch during the processing operation. After sterilization the bunches are placed in the upper end of a long sloping U - shaped trough. This trough is made of metal grating with bars spaced about one and one-half inches apart. As bunches tumble down the trough, metal beater arms, which enter the trough between the grating, strike the bunch knocking the fruit from it. (Stage three - digestion) After the fruit is stripped from the bunch it is elevated into a digestion tank. In this tank the projecting blades on a vertical rotating rod break up the fruit pericarp to prepare it for pressing. (Stage four - oil extraction) The cylindrically shaped press cage holds about 220 pounds of fruit. After it has been filled from the top it is covered and a press ram rises from below to squeeze the oil out of the fruit. (Stage five - oil clarification) The oil is pumped from the press into a clarification tank where the impurities settle from the oil. Then the oil is decanted from the tank into eight hundredweight drums for shipment to the port. (Stage six - nut and fibre separation) As the nuts and fibre tumble in a horizontal rotating cylinder, the fibre is stripped off the nuts and falls through holes in the cylinder wall while the nuts roll out the end of the drum. (Stage seven -

nut decortication) After the nuts are cracked mechanically some of the fine dirt and shells are removed from large shells and kernels. (Stage eight - shell and kernel separation) The shells and kernels are placed in a concrete tank filled with a mixture of clay and water. Differences among the specific gravity of the shells, kernels, and mud cause the kernels to rise to the surface and the shells to settle to the bottom of the mud. Then the kernels are strained from the mud, washed with clear water, dried on concrete floors and bagged for shipment to the port.

Budgeted Cost and Revenue

Average variable processing cost and average revenue.--The average variable processing cost is 29s 8d and the average revenue is 52s 3d (see Table 8.1). This average variable processing cost is composed of the cost of fruit and labor. It is lower than the other technologies studied because the Stork major mill has high technical efficiency in the oil and labor inputs. Since the Stork major mill can extract more of the oil contained in the pericarp only 4.7 hundredweight of wild palm tree fruit is required to produce one hundredweight of oil. At the average daily level of output oil is extracted from the fruit with a total skilled and unskilled labor input of only 0.7 man days per hundredweight of oil produced. This reduction in labor input per unit of output over the pioneer oil mill is even more significant than it appears because the Stork mill labor operates an additional processing stage where the fruit is separated from the bunch.

Annual fixed and general processing cost.--If a one and one-half ton of bunches per hour Stork mill which costs £55209.18. 0, installed in Okigwi Division, is depreciated for a 15 year life, the

Table 8.1.-Components of average variable processing cost and average revenue for a Stork major one and one-half ton mill in Okigwi Division, 1964

Item	Quantity per cwt. of oil produced[a]	Price of item per unit	Value per cwt. of oil produced
		s.d	
Fruit	4.7 cwt.	6. 0 per cwt.[b]	28. 2
Labor[c]	.5 man days[d]	3. 0 per day[e]	1. 6
Average variable processing cost			29. 8
Oil	1.0 cwt.	39. 6 per cwt.[a]	39. 6
Kernels	0.5 cwt.	25. 6 per cwt.[a]	12. 9
Average revenue			52. 3

a. Each of these items was derived from the case study.
b. Standard fruit prices are used for each of three locations, i.e., 6s 6d in Abak Division, 6s 3d in Eastern Nigeria, and 6s 0d in Okigwi Division.
c. The skilled labor is not included here, but is listed under general cost in Table 7.3.
d. One man day equals eight man hours.
e. This standard unskilled labor price is applied for all technologies operating anywhere in Eastern Nigeria.

annual depreciation on the mill is £3680.13. 2 (see Table 8.2).[2] The annual fixed cost which is the sum of the annual depreciation and interest on investment is £5612. 0. 1 for this firm (see Table 8.3). The annual total general cost is £1680. 4.11 and £1880. 4.11 for 150 and 250 day seasons, respectively. It is composed of the cost of repairs and skilled labor.

Average total cost.--At the average level of output during an eight hour day, 22.3 hundredweight of oil, the one and one-half ton Stork mill has average total cost of 60s 1d per hundredweight of

[2] A 15 years depreciation period was used rather than the 10 years recommended by S.C. Nwanze, op. cit., p. 244, because the experience with these plants in Eastern Nigeria indicates the longer depreciation period is a close approximation to the useful life of the plant.

Table 8.2.-Capital cost of a fully equipped Stork major one and one-half ton mill in Okigwi Division, 1964[a]

Item	Number required	Estimated life	Replacement cost	Annual depreciation
		years	£.s.d	
Fully equipped mill	1	15	48984.10. 0	
Building	1	15	6225. 8. 0	
Total			55209.18. 0	3680.13. 2

a. Straight line depreciation method, i.e., replacement cost divided by estimated life.

oil for the 250 day season (see Table 8.4). The average total cost declines from 73s 4d per unit of output to 52s 6d per unit of output as the large annual fixed and general costs are divided by more units of output. At similar levels of output per day the average assembly cost is considerably larger for the Stork major mill than the pioneer oil mill since bunches rather than fruit are transported to the Stork major mill. Since the average revenue is less than average total cost for all levels of firm output budgeted, this firm is operating at a loss. However, at all the levels of output budgeted the average revenue is greater than the difference between average total cost and average fixed cost so the firm can minimize its losses by continuing in operation.

Summary

A case study of a Stork major mill, recently installed in Eastern Nigeria by a private entrepreneur to process wild palm fruit, was used to analyze the operation of this technology. The processing operation

Table 8.3.-Annual fixed and general cost for Stork major one and one-half ton mill in Okigwi Division, 1964

Item	150 day season	250 day season
	£.s.d	
Depreciation on fixed capital investment[a]	3680.13. 2	3680.13. 2
Interest on fixed capital investment[b]	1932. 6.11	1932. 6.11
Total annual fixed cost	5612. 0. 1	5612. 0. 1
Repairs[c]	1380. 4.11	1380. 4.11
Skilled Labor[d]	300. 0. 0	500. 0. 0
Total annual general cost	1680. 4.11	1880. 4.11

a. This item is derived from Table 8.2.
b. This item is seven per cent of one-half the initial investment in capital equipment listed in Table 8.2.
c. This item is 2.5 per cent of the total investment in capital listed in Table 8.2.
d. This item includes an engineer at 15s per day, a clerk at 10s per day, a fruit buyer at 9s per day, and a manager at 6s per day. It is separated from variable labor cost because it does not change as output per day varies.

consists of eight stages i.e., bunch sterilization, fruit and bunch separation, fruit digestion, oil extraction, oil clarification, nut and fibre separation, nut decortication, and shell and kernel separation. This mill produces an average of 22.3 hundredweight of oil per day. To produce one hundredweight of oil an average of 4.7 hundredweight of fruit and 0.7 man days of labor are required. At the average daily level of firm output, the average total cost is 60s 1d for the 250 day season. Average revenue is lower than average total cost, but it is higher than the difference between average total cost and fixed cost so the firm minimizes its losses by continuing in production.

Table 8.4.-Budgeted average cost for a Stork major one and one-half ton mill in Okigwi Division, 1964

Item	Hundredweight of oil produced per eight hour day	
	22.3[a]	30.7[b]
	s.d	
Average variable processing cost[c]	29. 8	29. 8
150 day season		
Average general processing cost[d]	10. 1	7. 4
Average fixed processing cost[d]	33. 7	24. 4
Average assembly cost[e]	3. 0	3. 4
Average total cost	73. 4	64. 8
250 day season		
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a. This includes all labor for an eight hour day including both unskilled and skilled labor at the average daily level of output. One man day equals eight man hours or one woman day equivalent. One woman day equivalent equals eight woman hours or 32 child hours.

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[1]The term efficiency has different meanings in different contexts. It can mean the physical relation between output and input or monetary relationship between the value of output and the value of input. In a broader sense it may simply refer to the effective operation of an economy in which resources are used appropriately to yield high levels of output.

In this thesis it means the ratio between the value of output and the value of input for some specific palm processing technology. In this chapter it is called efficiency while in the next chapter it is prefaced by the word monetary to insure there is no confusion between its meaning and any broader definition of the term.

of very different sizes survive, and we may infer that commonly there is no large advantage or disadvantage to size over a very considerable range of outputs."[1] In Table 9.2 the five processing technologies are compared for two different sets of seasonal conditions. Under both sets of seasonal conditions, the index of efficiency is relatively constant for the screw press, hydraulic hand press and pioneer oil mill processing technologies. In the first comparison, the efficiency index is an average of 92 for the screw press technologies, 94 for the hydraulic hand press, and 95 for the pioneer oil mill. The hand method firms have an average index level of 83 while the Stork mill has an index level of 87. A similar pattern emerges in the second comparison where the technologies are compared during a 150 day season. Here the screw press, hydraulic hand press and pioneer oil mill have efficiency indexes of 93, 94, and 90, respectively. During the 150 day season, the hand method technologies have an average index level of 84 and the Stork mill has an index level of 71. The index remains relatively constant for either set of seasonal conditions while the average output per day increases from an average of 1.5 hundredweight of oil for the screw press processing technologies to 17.3 hundredweight of oil for the pioneer oil mill. Conversely, for the technologies with outputs per day of 0.2 and 22.3, the efficiency of production appears to be lower.

The importance of considering the efficiency index rather than the average total cost is apparent when they are compared in Table 9.2.

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[1]George J. Stigler, The Theory of Price, (New York: The MacMilliam Company, 1961) p. 144.

Table 9.2.-The relative efficiency of five processing technologies in Eastern Nigeria, 1964

Technology	Average revenue	Approximation of average season for each technology[a]: Average total cost	Approximation of average season for each technology[a]: Efficiency index	150 day season for all technologies: Average total cost[b]	150 day season for all technologies: Efficiency index
	----------s.d----------		Percent	--s.d--	Percent
Okigwi	42. 9	59.11	71	59. 1	73
Average hand method			83		84
Abak hand method	49. 5	51.11	95	51. 7	96
Abak screw press	48.11	51. 7	95	49. 5	97
Average screw press			92		93
Okigwi screw press	45. 6	50.11	89	49.10	89
Hydraulic hand press	51. 6	54. 5	94	54. 5	94
Pioneer oil mill	51. 4	54. 2	95	61. 5	90
Stork major mill	52. 3	60. 1	87	73. 4	71

a. This is 50 days for the hand method and screw press, 150 days for the hydraulic hand press, and 250 days for the pioneer oil mill and the Stork mill.
b. The average total cost is for the average daily level of output of each technology.

In this table, the average total cost alone indicates the screw press processing technology is the most efficient processing method for both sets of lengths of season compared; however, when the value of the output is considered also the three technologies have quite similar levels of efficiency.

Budgets testing constant efficiency.--Several budgets were developed to test the stability of the conclusion that the screw press, hydraulic hand press, and pioneer oil mill technologies have similar levels of efficiency (see Table 9.3 and 9.4). These budgets indicate that for either an increase or decrease in the price of fruit of 6d or 1s the three processing technologies stay within an index number range of four. If the wage rate is decreased 50 per cent the three processing technologies still stay within an index number range of four. None of these changes in the budgets alter the conclusion previously reached that the screw press, hydraulic hand press and pioneer oil mill have similar levels of efficiency. However, a wage increase of 50 per cent, increasing the output per day to plant capacity, and doubling the estimated life of the equipment improves the relative position of the large scale processing methods, i.e., the pioneer oil mill and the Stork major mill.

Changes in the magnitude of the components of average total cost.--There are major changes in the magnitude of the components of average total cost as the size of plant increases. Table 9.5 illustrates the decline in average variable processing cost from 58s 1d to 29s 8d as fixed factors are substituted for variable factors of production in the larger plants. For all of the technologies illustrated in

Table 9.3.-Efficiency indexes for alternative input prices for five processing technologies in Eastern Nigeria, 1964[a]

Technology	Present situation	Fruit price increase		Fruit price constant		Fruit price decrease	
		1s	6d	Wages Increased 50 per cent	Wages decreased 50 per cent	6d	1s
Okigwi hand method	71	64	68	63	82	76	81
Average hand method	83	75	79	75	94	88	94
Abak hand method	95	85	90	88	106	101	107
Abak screw press	95	85	89	88	103	101	108
Average screw press	92	82	86	86	99	98	105
Okigwi screw press	89	78	83	84	95	96	103
Hydraulic hand press	94	84	89	89	101	100	107
Pioneer oil mill	95	86	90	92	97	100	106
Stork major mill	87	80	84	86	88	90	94

a. These indexes are based on the average daily output during the lengths of season indicated in columns two and three of Table 9.2.

Table 9.4.-Efficiency indexes for capacity levels of output and doubled estimated plant life for five processing technologies in Eastern Nigeria, 1964.

Technology	Operation at capacity[a]	Doubled estimated plant life[b]
Okigwi hand method	72	71
Average hand method	83	83
Abak hand method	96	95
Abak screw press	99	96
Average screw press	94	93
Okigwi screw press	91	90
Hydraulic hand press	100	96
Pioneer oil mill	102	100
Stork major mill	100	98

a. This index is based on the capacity level of output per day during the lengths of season indicated in columns two and three of Table 9.2.

b. This index is based on the average daily output during the lengths of season indicated in columns two and three of Table 9.2.

Table 9.5 except the Stork mill, the average variable processing cost is the major portion of average total cost. While the average variable cost declines the average general processing cost increases from zero to 10s 1d, the average assembly cost increases from 0s 9d to 3s 0d, and the average fixed processing cost increases from 0s 3d to 33s 7d.

Table 9.5.-Components of average total cost during a 150 day season average level of output for five processing technologies in Eastern Nigeria, 1964[a]

Technology	Average variable processing cost	Average general processing cost	Average assembly cost	Average fixed processing cost
	-----------	-----------	s.d	-----------
Okigwi hand method	58. 1	0	0. 9	0. 3
Abak hand method	50. 7	0	.10	0. 2
Abak screw press	47. 4	0. 1	1. 0	1. 0
Okigwi screw press	48. 0	0. 1	1. 3	0. 6
Hydraulic hand press	46. 4	2.10	1. 3	4. 0
Pioneer oil mill	38.11	6. 0	1.11	14. 7
Stork mill	29. 8	10. 1	3. 0	33. 7

a. These costs are based on average daily output during the lengths of season indicated in columns two and three of Table 9.2.

Profitability of Palm Processing

Although the primary objective of the budgets developed in this thesis is to compare the five technologies, in a rough manner they also describe the profitability of the palm processing industry. They indicate average total cost is greater than average revenue for most technologies at most levels of output per day and length of season. The budgets illustrated in Table 9.2 for two sets of lengths of season show cost is greater than revenue for all technologies. The efficiency indexes developed by partial budgeting in Tables 9.3 and 9.4 indicate average revenue is less than average total cost under a variety of conditions. If the average assembly cost is deleted from

total cost or the fruit price is reduced by 6d per hundredweight, the average efficiency index does not increase above 100 so average revenue is not greater than average total cost. Decreasing the wage rate by 50 per cent or increasing the output per day from the average level to the capacity level results in one of the five processing technologies having an average revenue greater than average cost. Any lower wage rates or fruit prices makes the average revenue greater than average cost for most technologies. Conversely, the higher wage rates and fruit prices budgeted in Table 9.3 increase the amount average total cost exceeds average revenue.

Summary

Comparison of the five processing technologies indicates as the size of plant increases less fruit and labor are required to produce a hundredweight of oil. Efficiency is similar for the screw press, hydraulic hand press, and pioneer oil mill under a variety of budgeted conditions. As the size of plant increases the average variable cost component of average total cost declines in relative magnitude while the average fixed cost component increases. Average total cost is greater than average revenue for most levels of output per day and lengths of season described in the budgets.

CHAPTER X

GOVERNMENT POLICY

Introduction

This chapter discusses which palm processing technology would be most beneficial to the Eastern Region of Nigeria. The problem is analyzed by considering five questions relevant to policy decisions which affect the palm processing industry. What are the past trends in the palm industry? What are the important policy issues in Eastern Nigeria? Which palm processing technology would most closely attain certain individual policy goals? Which palm processing technology, if it was used throughout the region, would maximize the attainment of a group of policy goals? What specific policy actions should be undertaken by the Regional Government? The last two sections in this chapter describe the methods that can be used to affect the palm processing technology used in the Region or the palm processing industry as a whole and the future research that should be given highest priority in the palm industry.

Background Trends in the Palm Industry

Trends in the price of palm oil.--The total quantity of palm oil and the total outlay for palm oil purchased by the Marketing Board were relatively stable during the period 1956 through 1961 (see Table 10.1). The prices paid for oil changed only slightly during these six years.[1] However, in 1962 the Marketing Board reduced the price paid for palm oil.

[1] See Table 1.1, page 9.

For example, special grade palm oil, which constitutes most of the oil purchased, was reduced from £47.15.0 per ton to £40.0.0 per ton. During 1962 the quantity of oil and the total outlay for oil purchased by the Board both declined severely (see Table 10.1). The quantity of oil purchased declined from 156,030 tons in 1961 to 116,496 tons in 1962, and the value of palm oil purchased declined from £7,229,800 to £4,553,974. A partial recovery occurred in 1963, but the level of purchases and outlay prevalent from 1956 through 1961 was not regained.

Trends in the number of firms.--The increase in the number of screw presses sold in the Eastern Region during the 1950's indicates that economic conditions encouraged the adoption of this new technology.[2] Apparently, new firms were entering the industry during this decade, but the maximum number of firms in operation is not known. However, between 1960 and 1964 this trend was reversed. The author became aware of this new trend as he collected the data presented in this thesis. Several screw press processing firms were closed, and the owners of these presses indicated they had "no money to repair them when they broke down." These firms could not economically invest even the small sum required to repair the press. Some owners of screw press manufacturing plants in Uyo complained about the poor sale of presses while other plants had changed from manufacturing presses to manufacturing iron bed frames. Other observers of the industry document this new trend also. Hartley suggests the major reason for the new declining trend may be the reduction in the price paid to the producer and therefore the increased price differential

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[2]See Chapter V, page 48.

retained by the Marketing Board as a form of tax. "There is good reason to believe that this almost penal rate of 'taxation' has been the main factor in reducing known palm oil exports in 1962 to the very low figure of 119,000 tons."[3]

<u>The present economic environment</u>.--From this background material and the results of this study summarized in Chapter IX it is possible to hypothesize the following recent trends in the industry.[4] It appears that the relatively constant level of prices paid by the Marketing Board from 1956 through 1961 probably permitted the number of firms operating in the industry to reach a rather stable equilibrium level. This stability was disturbed by the change in price to cost relationships which occurred in 1962. Investments in processing equipment were made prior to 1962. After 1962 when the quantity processed and the price of palm produce declined, the average processing firms no longer had total revenue as great as total cost. Hence they continued in operation only when their revenue was equal to or greater than the difference between total cost and fixed cost. Some of the processing firms have already closed their plants, and other firms will close rather than replace their equipment when it wears out. This trend will continue until the industry approaches a new equilibrium level where the total cost is approximately equal to total revenue. During this period new firms lack an incentive to enter the palm processing industry. It is within this kind of an environment that the general policy issues of the palm processing industry must be related to the Eastern Region.

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[3]C.W.S. Hartley, <u>The Decline of the Oil Palm Industry</u> (Benin City: West African Institute for Oil Palm Research, June 1963), p. 2, (Mimeographed).

[4]See particularly page 99.

Table 10.1. The quantity and value of palm oil purchased by the Eastern Nigerian Marketing Board from 1956 to 1964.[a]

Year	Quantity Purchased	Total Value of Purchases
	-------tons-------	---------- £ -----------
1956	158,634	7,564,408
1957	151,353	7,156,004
1958	163,879	7,920,798
1959	166,690	7,710,420
1960	166,904	7,703,778
1961	156,030	7,229,800
1962	116,496	4,553,974
1963	133,452	5,219,920

[a]Nigeria Produce Marketing Company Limited, Oil Palm Purchases in the Federation of Nigeria, 1949 to 1964, (Lagos: Nigerian Produce Marketing Company, 1963), p. 4.

The Important Policy Issues in Eastern Nigeria

The Nigerian economy is faced with three general policy issues. One can be described as the monetarily efficient use of resources within the palm processing industry. The second involves the issue of employment and income levels in the economy. The third is the balance of payments position of the economy.

Monetary efficiency.--Why is the efficient processing of oil palm fruit important to the Regional Government? The government is interested in using the scarce resources efficiently in the oil palm industry so the economy can yield the largest possible total output. More efficient operations in production, processing and distribution would help improve the absolute advantage of Nigeria in relation to other countries producing fats and oils for the world market. More efficient processing would permit the Marketing Board to decrease the price they pay for oil without incurring a decrease in the quantity of oil supplied. Therefore, one of the goals of government policy might be to increase the monetary efficiency of the palm processing industry.

Employment and income.--The Regional Government is trying to increase the level of employment and income in the economy. Studies conducted by the Economic Development Institute in 27 major Nigerian towns in 1963 suggest that approximately 13 percent of the potential labor force in these towns was unemployed.[5] Packard states, "Nigeria has an unemployment problem. Population shifting from rural to urban areas is not absorbed into the economy's nonagricultural sector."[6] The extent of unemployment and underemployment in the agricultural sector is not known. The Government's activity in the Economic Development Plan indicates its strong interest in increasing the average income of the Nigerian citizens. Therefore, reducing the unemployment and improving the income per capita may be two more goals of government policy.

Balance of payments.--Packard clearly states the Nigerian balance of payments problem. "Merchandise imports consistently exceed exports. Nigeria's balance of payments remains in deficit and external assets are falling rapidly. At present rates, reserves will be exhausted in 3-4 years."[7] This problem can be improved by increasing the value of exports

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[5]Philip Packard, Report on the Nigerian Economy, (Enugu: Economic Development Institute, March 1964). (Mimeographed), p. 31.

[6]Ibid., pp. 42 and 43.

[7]Ibid., p. 41.

or decreasing the value of imports. Therefore two more policy goals in the palm industry would be to increase exports of palm oil and kernels and to decrease the importation of palm processing capital equipment and parts.

Palm Processing Goals

To assist effectively those who make policy decisions, an economist usually must undertake several closely related tasks. Often, he must identify policy issues and specifyalternative policy goals. Then the economist provides as much relevant information as possible about the consequences of pursuing each of these policy goals. When it is possible the consequences should be described in terms of both their direction and magnitude. If the direction or magnitude of the consequences cannot be determined it is necessary to specify what important factors must be considered to evaluate a particular line of action. This section indicates which palm processing technology, if it were used to process all the palm fruit in Eastern Nigeria, would most closely attain each individual goal.

Maximizing monetary efficiency.--If the goal of government policy were only to process each £'s worth of output for the least aggregate cost in terms of the value of the national resources required, processing palm fruit by the screw press, the hydraulic hand press, and the pioneer oil mill would all attain this goal.[8] Since these three technologies have similar relative monetary efficiency indexes, any of them can be used on the farm settlements, plantations, and rehabilitated palm plots.

Maximizing employment.--If the goal of government policy is to maximize employment in the palm processing industry, the hand method of

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[8]See Table 9.2, page 95

processing should be encouraged. If the hand method processing technology is used to produce the 140,000 tons of palm oil usually exported from Eastern Nigeria annually, 70,575 man years of labor would be used.[9] If the goal of monetary efficiency is pursued concurrently with employment in the pursuit of a broader form of efficiency, then the screw press processing technology should be encouraged. However, the monetarily efficient screw press method of processing would require only 29,150 man years of labor to produce 140,000 tons of oil.

Maximizing income per capita.--If the goal of government policy is to maximize the income per capita received by workers in the oil palm industry, then processing with the Stork major mill should be encouraged. The higher wage rates paid to the more highly skilled laborers who operate these plants would result in an average wage per capita of 5s per day.

Maximizing oil yield to increase exports.--If the government policy goal is to maximize the quantity of oil extracted from the fruit processed in Nigeria the Stork major mill should be used. If the fruit used to produce 140,000 tons of oil exported annually was processed by the Stork mill rather than the screw press and hand method, 53,617 additional tons of oil would be available for export annually.[10] If the goal of monetary efficiency is pursued simultaneously with the goal of maximizing oil yield, the pioneer oil mill should be used to process oil. An additional 14,000 tons of oil could be obtained if the fruit required to produce 140,000 tons of oil by the hand and screw press were all processed in pioneer oil mills.

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[9] One man year equals 365 eight hour man days or 365 woman day equivalents.

[10] The oil extraction rates for each technology are summarized in Table 9.1.

Minimizing the imports of capital equipment.--If the goal of government policy is to minimize the value of imports, the hand method of processing should be used. The hand method requires no imported capital equipment so this would minimize the value of imports. If the goal of monetary efficiency is pursued concurrently with the goal of minimizing imports, the screw press method of processing should be encouraged. The screw press used all locally made material except for the internally threaded press plate support.

Evaluating Each Technology in Terms of the Group of Policy Goals

The previous section has shown how the adoption of one particular processing technology can maximize the attainment of an individual policy goal. But maximizing one policy goal may not maximize the overall benefit to the economy. This broader objective requires selecting the technology which maximizes some blend of several policy goals, each of which may be only partially obtained. However, the overall bundle of goals achieved can benefit the economy more than the maximization of one goal alone. To reconcile these five policy goals they must be expressed in some measurable common denominator. A monetary common denominator will be used to determine which processing technology yields the greatest overall attainment of this group of goals.

Assumptions.--Assume the Eastern Marketing Board purchases for export 140,000 tons of palm oil annually.[11] Assume this oil is all obtained from fruit processed by the screw press processing technology.[12] Assume the

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[11]See Table 10.1.

[12]See Chapter I, p. 9, for a discussion of the role of the small processing units in the Nigerian environment.

inefficient processing technologies i.e., the hand method and the Stork major mill would not survive in the long run in the competitive environment that exists in the palm processing industry. Assume the level of unemployment in the economy discussed earlier precludes the employment in other jobs of the workers replaced by more capital intensive methods of processing palm fruit.[13]

Under these conditions what would happen to the attainment of the group of policy goals if the screw press processing technology was completely replaced by the hydraulic hand press or the pioneer oil mill?

Replacing screw presses with hydraulic hand presses.--If the fruit processed by the screw press for this export market was instead processed by the hydraulic hand press more oil would be extracted from the fruit. If the world price of oil was £80 per ton, sale of the additional oil extracted by the hydraulic hand press would increase Marketing Board gross revenue by £355,420 (see Table 10.2). The additional processing equipment required to process this oil at the average daily level of output found in this study would increase the annual payments for depreciation, interest on investment and repairs by £674,044 annually. While the number of people employed in processing would decline, the higher wages paid to the more skilled workers who operate the hydraulic hand presses would result in an increase in the total wages paid for processing by £332,843.

In terms of the issues and goals discussed previously in this chapter the change from screw press to hydraulic hand press would make no change in the monetary efficiency of the processing industry. But the number of

[13]See the section of this chapter entitled employment and income.

people unemployed would be increased and the total wage bill paid in the economy would increase. The balance of payments would not be improved because the change in value of imports would be twice the change in the value of exports. If the increase in income and the increase in exports are considered as positive effects on the economy while the increase in imports is considered as a negative effect, the overall benefit of this change to the economy would be £14,219. With the magnitudes used and the variability in the data this figure cannot be considered to be significantly different from zero. Hence, there is no advantage to the Nigerian economy in changing from the screw press processing technology to the hydraulic hand press processing technology.

Table 10.2. Annual magnitude of selected economic variables for different methods of processing 960,000 tons of palm fruit in Eastern Nigeria during 1964[a]

Line Number	Technology	Wage payments	Marketing Board Gross Revenue[b]	Depreciation, interest on investment, and repairs
		£		
1	Screw Press	1,605,012	11,200,000	359,224
2	Hydraulic Hand Press	1,937,855	11,555,420	933,268
3	Line 2 Minus Line 1	+ 332,843	+ 355,420	+ 674,044
4	Pioneer Oil Mill	507,100	12,320,000	1,680,360
5	Line 4 Minus Line 1	-1,097,912	+ 1,120,000	+ 1,321,140

[a]This is the quantity of fruit required to produce 140,000 tons of oil by the screw press processing method. This quantity of oil is about the average amount exported from Eastern Nigeria annually.

[b]Assumes £80 per ton received by the Marketing Board for the oil. Note that only half of this amount, £41, is paid for this oil by the Marketing Board.

Replacing screw presses with pioneer oil mills.--What would be the economic impact on the Eastern Nigerian economy if the fruit required to produce 140,000 tons of oil with the screw presses was processed in pioneer oil mills? The initial impact of substituting the capital intensive pioneer oil mills for the labor intensive screw presses would be a decrease in employment of 20,720 and in total annual wages paid by the processing industry of £1,097,912. The higher oil extraction rates from pioneer oil mills would increase Marketing Board annual oil revenue by £1,120,000 if the world price of oil were £80 per ton. The annual outlays for depreciation, interest on investment, and repairs by the processing industry would increase £1,321,140.

This change does not affect the monetary efficiency of processing operations, but it does reduce both the employment and wages paid in the industry. The increase in the value of exports is matched by a similar increase in the value of imports (see Table 10.2). If the increase in exports is treated as a positive effect on the economy, while the decrease in wages and the increase in imports are considered to have a negative effect, then there is a negative net benefit to the economy of £1,299,052 resulting from the change to pioneer oil mill processing equipment. Hence, there is no reason for the government to encourage the introduction of the pioneer oil mill processing technology in the Eastern Region.

General Policy Conclusions

The above analysis of policy alternatives, which is restricted by the assumptions indicated, suggests the following general policy conclusions. A great deal of unused capacity exists in the palm processing industry. Changing from the present methods to other monetarily efficient technologies appears to have no benefit for the Nigerian economy. Therefore, the government of Eastern Nigeria probably should not invest in more equipment to process wild palm fruit at this time. This conclusion should be reviewed as changes occur in the price to cost relationships in the palm processing industry. Furthermore, changes in the wage level or unemployment level of the general economy would affect this general conclusion.

The Hydraulic Hand Press

The special hydraulic hand press problem requires individual attention in a chapter concerned with government policy. There are over 900 hydraulic hand presses in storage in Port Harcourt. The investment in these presses has already been made so the decision to invest discussed above is no longer the appropriate question. Since the relevant alternatives are whether to leave these presses in storage or to develop a method to distribute them throughout the Eastern Region, they probably should be distributed for processing. While this distribution would increase the overcapacity in the processing industry, it would permit a partial recovery of the foreign exchange import outlay through increased oil exports and increased domestic wages. If the new presses were installed on the farm settlements and the rehabilitated palm plots where new trees will be bearing fruit in a few years, they would have a minimum adverse impact on firms presently operating in the industry. The presses can be distributed by two methods discussed previously, that is, extensive training of the managers and reducing the price of the presses.[15]

[15]This solution is treated in considerable detail in W. Miller, op. cit., pp. 6-24. The price of the press was reduced to £250 in March, 1965.

The training operation can be organized through the Ministry of Agriculture extension service. These actions should be undertaken soon to preclude the possibility of physical deterioration of the presses in storage.

Methods to Affect the Palm Processing Industry

Several alternative methods of government policy are available to affect the palm processing industry. Some of these methods may be more useful as selective tools with a direct impact on one particular technology. Others may be more useful as general tools with an overall impact upon all five technologies.

Changing capital investment.--One method of control is through altering the price of palm processing equipment. If the capital investment required to purchase the processing equipment were to be lowered, the firms purchasing this equipment would have a lower average total cost per unit of output. Furthermore, they would receive a higher rate of return on their investment. This lower price would change the relative monetary efficiencies of the five processing technologies. The price reduction could be obtained by imposing an import subsidy or by reducing the sale price to the private entrepreneur if the government owns the equipment. For example, the government could place a 50 per cent of value import subsidy on the Stork mill. Alternatively, the Fund for Agricultural and Industrial Development could reduce by 50 per cent the price of the hydraulic hand press.

Changing the price of outputs or inputs.--The government presently sets the price for the outputs of the palm processing industry, that is, oil and kernels. The rate of return on investment and the profitability of all processing technologies can be increased by increasing the price paid for these products. This change would increase the average revenue received per unit of output, increase the amount of capital and labor devoted to the palm industry, and increase the quantity of oil and kernels produced.

A change in the price-cost relationship could be secured by the alternative method of changing the price of inputs purchased by the firms, that is, labor and fruit. There is presently a minimum wage rate in Eastern Nigeria. Where it is applied the cost of processing is increased. The effect of this minimum wage rate is not neutral among technologies. It has a potentially greater chance to be applied in the larger plants where it can be more easily enforced than in the small processing plants deep in the bush. Under these conditions increases in the minimum wage rate would improve the relative position of the small plants in the bush in relation to the larger plants where the minimum wages are enforced.

Changing managerial skill.--Training managers to organize and operate the firm more efficiently would reduce the cost of production per unit of output. This type of training should include more than simply showing the manager which drum to use and when to use it. It should provide the manager with knowledge of the factors influencing cost and revenue. There is some indication that the return to the economy for investing in training the palm processing firm managers may be relatively high.[16] One explanation for the failure of the hydraulic hand press to have high extraction rates or high returns is that this new technology was combined with unskilled managers. The farm settlement schemes success may be primarily due to the allocation of the best human resources in the Eastern

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[16] Ibid.

Region to the organization and operation of farm settlements. Managerial training as a method to affect the palm processing industry certainly deserves careful consideration since it can be selectively applied to one technology or generally applied to all technologies.[17]

Future Research Priorities

Supply response.--The major area of research that should be examined first is the impact of Marketing Board pricing policy upon the quantity of palm products produced. The historical record clearly indicates that reductions in the price of kernels and oil has caused a reduction in the quantity exported. Empirical analysis which quantifies this supply function can assist in comparing the alternative of increasing economic growth through higher prices and private investment with the alternative of increasing economic growth through lower prices and government investment.

Vertical integration.--A study of the changing structure of the marketing system for palm products might show that rapid vertical integration is occurring. It appears that the licensed buying agents may be obtaining ownership or control of the transportation, processing and production. They are purchasing or leasing the lorries which transport oil and kernels to the port, are buying pioneer oil mills sold by Eastern Nigeria Development Corporation, and are actively participating in the government rehabilitation program. This development of vertically integrated operations may significantly reduce the cost of producing and marketing palm products when the various production and marketing activities can be closely coordinated by one controlling unit.

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[17]Work being conducted at the Institute of Administration in Enugu should provide valuable insights about the gain available from improving managerial skill.

Summary

If the screw press, the hydraulic hand press, and the pioneer oil mill are all used for processing palm fruit, efficiency in the palm processing industry will be maximized. Use of the hand method processing technology will maximize employment and minimize the value of capital imports. Use of the Stork mill will maximize the oil yield for export and income per capita of the employees. Changing the method for processing palm fruit for the export market from the screw press to the hydraulic hand press or the pioneer oil mill does not benefit the economy because advantages of higher oil exports are balanced by capital imports. The government has several methods available to effect the type of technology used for palm processing or the cost and revenue for all technologies. They can change the cost of capital equipment, change the price of inputs or outputs, and change managerial skill. Under the present price and cost relationships in Eastern Nigeria there is an overinvestment in the palm processing industry. Therefore, the government probably should not plan to make additional investments in processing equipment at this time. The hydraulic hand presses already owned by the Eastern Government can be distributed by initiating a managerial training program and by making price reductions for the presses. Future research should give highest priority to studies of the supply response and vertical integration in the palm industry.

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