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THE NIGERIAN PALM OIL INDUSTRY†

The processing of palm fruit is the most important processing activity carried on in Nigeria.[1] The end products, palm oil and palm kernels, have traditionally composed 15 to 20 per cent of Nigeria's exports; in 1965 their combined value was £40 million (*26,* p. 20). In addition, palm oil is an important item in the Nigerian diet (as part of the traditional soup or sauce) and is used as an illuminant, cooking fat, and soap ingredient. Implicit production estimates based on marketing board purchases of palm kernels, for which there is little domestic use, indicate that internal consumption ranges from 80 to 150 per cent of exports.

I. BACKGROUND

The wild oil palm is native to West Africa. The area in which it grows, "the palm belt," covers approximately 70,000 square miles, largely in Southern Nigeria. In competition with surrounding vegetation, the wild palm requires about 15 years to rise above the undergrowth (about 40 feet) and commence bearing fruit, as against four years for the plantation-grown tree. The individual palm fruit is oval shaped, about an inch and a half in length and grows in clusters or bunches of several hundred. The fruit is composed of an outer skin, an oil-bearing layer of fiber (the mesocarp) covering the palm nut, and inside the nut, the palm kernel. Compared to carefully bred plantation varieties, wild palm fruit has a relatively large and thick-shelled nut, and a commensurately smaller oil-bearing mesocarp. The difference in yield between a wild palm tree and current cultivated varieties is on the order of one to five (*5*; *34,* p. 47). Harvesting is continuous, although there is a sharp seasonal rise from March to May. Wild palm is harvested by climbing the tree with the aid of a rope, cutting the bunches with a machete and letting them drop to the earth. In the case of the much shorter thick-trunk plantation tree (about 15 feet high), the bunches can be cut from the ground by means of a harvesting hook.

It is clear that palm oil production based on plantations has very considerable

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[1] The major references which provide the historical and descriptive background for this study are *10, 15, 22, 27, 29, 31,* and *33.*

In this article the word "ton," without further modification, means the long ton of 2,240 pounds.

TABLE 1.—WORLD EXPORTS OF PALM OIL, SELECTED YEARS, 1923–65*
(*Thousand tons*)

	1923	1937	1959	1965
Nigeria	128	146	184	156
Indonesia	7	194	102	123
Congo	16	68	181	79
Malaya	—	43	77	138
Other	40	45	41	27
Total	191	496	585	523

* Data from Great Britain, Commonwealth Economic Committee, *Vegetable Oils and Oilseeds,* various issues.

advantages over an industry based on natural palmeries. In addition to higher oil yields per tree, processing in large plantation mills gives a greater extraction efficiency, a better quality oil,[2] and—owing to planned full-capacity operation—lower processing costs than are obtainable under a peasant smallholder system (*32,* p. 25). Despite these advantages, the colonial administration resisted the determined efforts of William Hesketh Lever in 1907, 1920, and 1925 to establish such plantations in Nigeria. Lever was anxious to secure a raw material supply for the European soap industry. However, upholding the "dual mandate" the colonial government was even more determined that the agricultural resources of the West African dependencies be developed "through the agency of their indigenous populations" and that as a "fundamental principle" no non-native would be allowed freehold land rights (*15,* p. 191). Efforts of the Nigerian government since the late 1950's to attract foreign investment into the plantation field have been frustrated by the heavy export tax involved in compulsory sales to the marketing board; indeed most of the 13,000 acres of palm oil plantation in the hands of expatriates is being replanted with rubber trees, a product not controlled by a marketing board.

Since the 1920's, informed observers have unceasingly predicted the imminent extinction of Nigeria's native industry by efficient plantation producers. In the prewar period, the Dutch plantations in Indonesia were going to ring the death knell on Nigeria's native industry. "The West African producers felt, for the first time, the pressure of competition which was growing at a sensational and menacing speed. It was no longer a spirit of greed, but one of fear, which dominated the discussion" (*15,* p. 191). Starting from scratch in the early 1920's, in little more than a decade Indonesia had overtaken Nigeria as the world's leading exporter; however, after the war and the removal of the Dutch, expansion was replaced by decline and stagnation (Table 1). In the postwar years, Belgian and British plantations in the Congo (concessions granted to Lever in 1911) showed a similarly rapid growth; but once again political disorder since 1960 has converted expansion into decline. The current threat to Nigeria's supremacy, in terms of rate of growth of output, is Malaya; and again political circumstances, whether generated from internal communal stresses or

[2] The possibility of obtaining higher quality oil stems from (1) processing bunches rather than loose fruit, (2) less bruising as a result of the shorter fall, and (3) a closer interval between harvesting and extraction.

external nationalism, can be envisaged which might disrupt the expansion of Malaya's plantation economy. In short, over the past five decades the economic inefficiency of the indigenous smallholder system has been offset by the long-term political vulnerability of the foreign-managed plantation system.

The colonial administration, however, did not rest content with just preserving the native smallholder system. It set out to increase the technical efficiency of indigenous production, and thereby its competitiveness in the world market, by introducing reforms on two fronts—palm grove rehabilitation and improved processing techniques (*14*). Although it is the processing aspect which is the subject of our inquiry, for a full understanding of the problems involved it is necessary to review, if only briefly, the principal developments on the agricultural side.

Primary Production

In 1927, after a number of years of experimental breeding,[3] the Department of Agriculture began to distribute free selected seedlings to farmers for the establishment of cultivated palm groves (*15*, p. 240). In 1935 the Cultivated Palm Ordinance provided financial incentive to farmers to undertake such planting by way of a rebate of the export duty. However, by 1938 only 5,530 farmers out of nearly one million had planted these seedlings, 9,213 acres in all (*15*, p. 242). There were many reasons for this disappointing performance. Principal among these were plot fragmentation and land tenure complications, difficult to administer and inadequate financial incentives,[4] periodic shortages of seedling supplies,[5] the absence of significant price differentials for higher quality oil, and fear that the government would eventually impose a tax on the planted trees as it had done in some cocoa districts (*29*, p. 236). While Professor Hancock has stressed inadequate agricultural extension efforts (*15*, p. 245), Richenda Scott points out the then as yet unsolved technical problems (*29*, p. 242):

> Over 3,000 acres of palm groves have been planted under the supervision of the Department of Agriculture, but not one has proved a complete success. A serious falling off in yield occurs after the ninth or tenth year, while even peak years have shown yields much below those of the Far Eastern plantations. The cultivated palm tends to exhaust the fertility of the soil more rapidly than the wild palm growing under natural condi-

[3] A botanical garden was established in Calabar in 1893 by the Consul-General; palm seed beds were started in 1913 and taken over by the Department of Agriculture in 1921. In 1948 the West African Institute for Oil Palm Research (WAIFOR) was established by a £1 million grant from the Colonial Development and Welfare Act.

[4] "If a grower registered his plot with the Government and the oil produced by him was under 5 per cent f.f.a., he was then to receive a full rebate of the export duty; if his oil was between 5 and 8 per cent he would receive nine-tenths of the rebate. But he was only allowed to include the oil produced from the registered palms, and if he was unable personally to plant 15 acres, he had to become a member of a palm oil cooperative society. This scheme, however, proved abortive; though there were a number of planters and societies with sufficient acreage, they were unable to produce oil of the requisite standard as the difficulties encountered were too onerous . . ." (*29*, p. 235). As will be seen later, when substantial price differentials were introduced these difficulties were quickly overcome.

[5] Until 1938 when government supplies became adequate, the United Africa Company (UAC) provided seedlings free of charge from its plantation at N'dian in the Cameroons. In 1936 the government granted UAC a 6,000 acre plantation concession near Calabar in the hope that it would have a demonstration effect on cultivation practice in the surrounding areas. UAC has a second palm plantation in the Midwest which it inherited from a much earlier period.

> tions, for in the bush or dense palm grove the nonbearing palms and other trees provide considerable plant nutrients, which they draw from the subsoil and from which the palms in bearing benefit. This supply is lacking in the carefully spaced palm groves of 60 trees to the acre.
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> . . . At the present time [1943] Nigerian farmers are not being encouraged to start oil palm plantations until methods of combating the resultant soil deterioration have been explored.

After the war facilities for research into soil fertility and other problems were greatly expanded by the establishment of the West African Institute for Oil Palm Research. WAIFOR's investigations have added much to the knowledge of environmental factors which shape the oil palm economy and, at the applied level, have recorded significant achievements in the following areas: the breeding of stable hybrid high-yielding palm varieties; large-scale production of selected seedlings for distribution by regional ministries of agriculture;[6] disease control; optimum cultivation practice; improvement of soil fertility; and more efficient methods of oil extraction.[7] In the field of basic research WAIFOR investigations have revealed that as a result of comparatively uneven rainfall, i.e., a long dry season, a smaller amount of sunshine and nutrient-deficient sandy soils, Nigeria enjoys a lesser natural advantage in primary production than its major competitors, Malaya and the Congo. Taking an example at the applied level, in the prewar period the Department of Agriculture recommended the use of manure, lime, and cover crops as techniques for maintaining and improving soil fertility, with little success. Later spectrographic analyses of palm leaves revealed "confluent orange spotting," a result of potassium deficiency. The subsequent use of potassium chloride fertilizers has brought very substantial increases in yield, sometimes as high as 100 per cent. To cite a second example, a large proportion of the seedlings distributed by the regional ministries of agriculture were failing to survive or showing very poor growth owing to the loss of the ball of earth around the root. WAIFOR discovered in the mid-1950's that by cutting the roots six inches from the base of the plant one month before transplanting, root growth was sufficiently stimulated to permit long distance carriage and successful replanting without the ball of earth.

A second major postwar development has been the shift in government policy to promote the establishment of large-scale plantations—not by foreign investors but by farm settlement schemes or through the development corporations.[8] The first such scheme at Kwa Falls near Calabar was initiated in 1948 for the purpose of resettling some 200 farming families from the overcrowded areas of the Eastern Region. Owing to a very low level of grove maintenance, failure to follow the advice given by the Ministry of Agriculture, and a general lack of enthusiasm on the part of the settlers, the scheme was abandoned in 1955, the land then being used to form the nucleus of the first plantation of the Eastern Nigeria Development Corporation (ENDC). By 1964 ENDC had established five plantations with some 19,000 planted acres. Another 2,000 acres had been

[6] Over the last decade the acreage equivalent of seedling distribution in the East has been about 2,000 acres per year; however, only a very small fraction of this is realized in successful plantings.

[7] This paragraph is based on *16*.

[8] The material in this paragraph is drawn from *20*.

planted in the various farm settlement schemes since their commencement in 1961. In the West some 17,000 acres have been planted in plantations of the Western Nigeria Development Corporation and 3,000 acres in farm settlements. The two older UAC plantations of 6,500 acres each, one in the East and one in the Midwest, are in the process of being replanted with rubber trees.

The third major development in palm cultivation since the Second World War has been the recommencement of a much improved program for palm grove rehabilitation. In the place of the complicated export duty rebate arrangements of the 1930's, the new scheme, begun in 1954 and financed by ENDC, initially provided direct payment of the following subsidies per acre: 30*s.* on felling and clearing unproductive wild palms, 30*s.* on the planting of seedlings, 19*s.* a year for four years of satisfactory maintenance—each step to be certified by the Ministry of Agriculture. In 1956, in order to promote greater care by the farmers, the second payment of 30*s.* was divided into 15*s.* on planting and 15*s.* after the following dry season if plant losses were less than 10 per cent. The program was not successful: less than 3,000 acres were rehabilitated in seven years. The primary bottleneck, according to annual reports of the regional Ministry of Agriculture, was delay and sometimes failure of ENDC to disburse the agreed-upon subsidies. In the 1962–68 Development Plan, £1.9 million was set aside for the rehabilitation of 60,000 acres over the five-year period. In order to encourage consolidation of land holdings, it was specified that a farmer must have five acres to qualify. The earlier subsidy of £5 per acre was increased to £10, plus an additional £8 in kind (seedlings, fertilizer, etc.). The area of palm groves rehabilitated since 1954 in Eastern Nigeria has been as follows (*4*; *9*, p. 20):

	Acres planted		Acres planted
1954	97	1960	687
1955	62	1961	—
1956	146	1962	1,761
1957	—	1963	3,793
1958	163	1964	10,480
1959	1,531	1965	13,616

The results of the first two years of the 1962–68 scheme were disappointing. As in earlier years, long delay in payment of the stipulated subsidies was a significant factor contributing to the shortfall (*6*, p. 6). No less important than the number of trees planted is the standard of cultivation which determines eventual yields. Field observations by C. K. Eicher and W. L. Miller in 1963 disclosed that the quality of naked-root seedlings varied considerably, that planting and application of fertilizer were untimely, and that standards of maintenance were low (*10*). In appraising these facts the investigators pointed out that agricultural extension staff responsible for palm cultivation had been deployed without any apparent rhyme or reason; while only four demonstrators were assigned to the three major producing provinces of Uyo, Calabar, and Port Harcourt, 21 had been posted to the relatively unimportant province of Abakiliki. However, the encouraging results for 1964 and 1965 suggest that some of these problems—payment of subsidies and the effective deployment of extension advisers—have been substantially overcome.

It is still too early to judge how successful current measures will be in narrowing the gap in agricultural yields between Nigeria and her competitors. So far large-scale government-run plantations have been only moderately successful; the magnitude of the managerial and technical problems involved are such that it is hard to imagine large Nigerian-owned and operated plantations making a significant contribution to total output, at least for the next few decades.[9] Farm settlement schemes are likely to be more successful. Regarding the rehabilitation of natural palmeries, in Professor Hancock's opinion lack of funds and personnel and inadequate government propaganda were responsible for the little progress achieved during the 1920's and 1930's; deficiencies in these areas have been more than made good in recent years. Equally the scientific and ecological knowledge necessary for a successful transformation is now available. But such qualitative factors as the efficiency with which the Ministry of Agriculture implements its program and the caliber and motivation of the extension workers could adversely affect the final outcome. Last but not least, the level of prices paid by the marketing board will have a critical influence on planting and cultivation practices.

II. PROCESSING TECHNOLOGIES

Having sketched in the major agricultural developments we may now proceed to the processing side of the palm oil industry. Palm oil extraction involves four steps: (1) softening of the palm fruit by heating, e.g., fermentation, sterilization; (2) maceration; (3) oil extraction; and (4) clarification. In carrying out these operations there is considerable choice of both technique and scale of operation. One of the interesting features of the Nigerian palm oil industry is that technically inferior, labor-intensive methods have proved economically more efficient than large-scale, more capital-intensive alternatives.

The traditional methods of extracting palm oil were first described in a series of papers published in the *Annual Bulletin of the Department of Agriculture* 1922–24 (*12*). These consisted of the "hard oil" and the "soft oil" processes; the former, which produced an oil which is semihard at air temperature, is thought to have been the more prevalent of the two up until about 1940.[10] In the "hard oil" process the fruit bunches are brought to the native's compound, stacked in piles and covered with palm fronds or plantain leaves and left for about four days to loosen. After the fruit is shaken from the bunches it is left to ferment for another six days or so for further softening of the mesocarp. Then, approximately ten days after harvesting, the fruit is placed in a mortar—initially a rock-bottomed, wood-lined pit, later half of a 44-gallon drum—where it is pounded with long wooden pestles.[11] The macerated pulp is again left to undergo fermentation for 12 hours and then, after adding boiling water, a second pounding is administered. The pulverized fruit is now ready for the third step, oil extraction. This is carried out by applying pressure to the pulp—either by wringing in

[9] For a discussion of the performance of publicly owned plantations, see *1* and *8*.

[10] No records of the quality of Nigerian palm oil exports were kept until the establishment of the marketing boards in 1939.

[11] William L. Miller reports that in 1964 in two areas in Abak and Okigwi divisions, processing was carried out on a considerably smaller scale, the maceration being administered in a small wooden mortar (*24*, p. 35).

a net or by trodding upon in an inclined open-end "canoe." The wrung pulp still contains the nuts which are now separated from the fiber; later the nuts are individually cracked between rocks to yield the palm kernel. The process of softening, pounding, and squeezing is then repeated a second time. The mixture of palm oil and water so obtained is boiled in a large pot and the oil skimmed off.

The "hardness" of palm oil is determined by its free fatty acid (f.f.a.) content. In its natural state palm oil is composed of glycerides—stable molecules of fatty acids and glycerol. When the fruit becomes overripe or is bruised, e.g., in falling from the tree, enzymes present in the cell tissues are activated and, unless destroyed by the application of heat, break down the glyceride molecules into glycerol and free fatty acids. The quality of the oil is inversely related to the f.f.a. content. Because the enzymes are not sterilized in the hard oil process just described and because fermentation for its softening effect is protracted, the resultant oil has a high f.f.a. content, ranging from 20 per cent upwards depending upon the extent of fermentation.

To produce an oil with a lower f.f.a. a "soft oil" process was used, which since the early 1940's has become the only traditional method to be employed. This process differs from the "hard oil" techniques primarily in that the fruit is sterilized at a fairly early stage. The bunches are left to soften only one to three days after harvesting and then the fruit is picked off by hand and steamed in a pot of boiling water, which neutralizes the enzymes and softens the fruit for pulling. The f.f.a. content of oil obtained by this process can be as low as or lower than that achieved by the most mechanized techniques. The disadvantages of the "soft oil" vis-à-vis the "hard oil" process are that a slightly smaller proportion of the extractable oil is realized, the early removal of fruit from the bunch requires more labor, and the initial boiling entails extra fuel costs. Thus it was not until significant price differentials were offered for the better quality oil that the "soft oil" process became dominant.

In the early 1920's the Department of Agriculture began investigating ways of improving the efficiency of native processing. Improvements on existing practices were effected in the area of ancillary equipment, e.g., drying tables, separation boards, barrel halves, and sequence timing. The major advance, however, was the introduction of a screw press for extracting the oil. After testing a number of makes the Duchscher press manufactured in Luxemburg, with a 22-gallon capacity and costing £13, was found to be suitable. The press economized on labor time and achieved a substantially higher extraction rate.[12]

The Duchscher screw press was first introduced in the late 1920's. Sales of the press were initially slow, but after 1934 hire-purchase terms arranged by the Native Administration, associated with higher palm oil prices during 1935–37, resulted in a moderate increase (*29*, p. 236). However, with the collapse of prices in 1938 the slow advance of the screw press was temporarily halted. The Department of Agriculture's *Annual Report* for 1938 explained why depressed prices operated against the more advanced technique, a phenomenon no less relevant in the 1960's.

[12] The extraction rate is the weight of the oil obtained expressed as a per cent of the weight of the fruit prior to processing. An alternate measure is extraction efficiency which is the weight of the oil obtained expressed as a per cent of the total oil content.

> In spite of the higher proportion of oil which can be produced by means of the press, the owner can seldom make a profit from the processing fee charged for extracting the oil of his neighbors. The market price of fruit approximates closely the value of the oil and kernel which it contains (the labour of extraction by native methods apparently being valued at nil) and the extra oil extracted by the press at low prices barely covers working costs (*29*, p. 237).

With sharply rising producer prices after the war the number of screw presses grew rapidly (Table 2). From the original £13, the price of the press rose to £30 in 1948, £65 in 1953, and fell (with the commencement of local manufacture circa 1954) to £15–£40 in 1964, the price varying with the size of the press. Up until 1953 the figures for the number of presses represent cumulative sales; whether discarded for reasons of age or temporarily out of operation for repairs, the number of presses in use at any one time was undoubtedly a good deal lower than the cumulative total. The 1963 figure is the number of screw presses reported to be in use in the Eastern Region by the Ministry of Agriculture.

In the early 1930's the United Africa Company began work on developing a small-scale power unit which would fall midway between the screw press and the large-scale plantation oil mills. It was felt that the traditional native methods, even when incorporating the screw press, resulted in relatively low extraction rates, poor quality oil, and consumed labor time which might otherwise be devoted to additional fruit collection (*31*, p. 3ff.). William Lever's experience at Opobo and the government's trial scheme of the late 1920's had shown that "central factories," the technical equivalent of large-scale plantation oil mills, servicing large areas of wild stands could not count upon a steady supply of fruit at the required volume of intake (*29*, p. 234). UAC's Pioneer mill, as it came to be known, was designed to embody most of the technical advantages of large-scale processing and yet be small enough to be compatible with what was con-

TABLE 2.—NUMBER OF SCREW PRESSES, AND PRODUCER PRICE OF PALM OIL IN EASTERN NIGERIA, SELECTED YEARS, 1930–63*

Year	Screw presses[a] (*number*)	Producer price of palm oil (*£ per ton*)	Year	Screw presses[a] (*number*)	Producer price of palm oil (*£ per ton*)
1930	24	16	1945	1,300	12
1931	31	6	1947	2,076	15
1932	58	10	1949	2,671	43
1933	76	7	1951	4,481	55
1934	100	5	1953	5,333	75
1935	173	11	1955	....	58
1936	390	11	1960	....	48
1937	734	13	1963	(3,893)	40

* Data from Richenda Scott, "Production for Trade," in Margery Perham, ed., *The Native Economies of Nigeria* (Part II, London, 1946), p. 237; Eastern Nigeria, Agricultural Division, *Annual Report, 1962–63* (Enugu, 1964), G. K. Helleiner, *Peasant Agriculture, Government, and Economic Growth in Nigeria* (Homewood, Illinois, 1966), Table V-F-6; and United Africa Company, *Statistical and Economic Review*, March 1954, p. 7.

[a] Cumulative sales up to 1953 for all Nigeria; the 1963 figure is the number reported in use in the East by the Regional Ministry of Agriculture.

sidered a realistic radius of fruit collection—namely, 5 miles by bush path, 7 miles by road, and 15 miles by water (*31*, p. 10). It was originally designed to cost £1,000 and to be owned and operated by local cooperative societies.

The essential components of a Pioneer oil mill are a sterilizer into which the fruit is first fed for 16 minutes of steaming, a digester (an enclosed set of revolving and fixed arms) which separates the mesocarp from the nut, a centrifugal basket where the oil is spun from the mesocarp, and clarification tanks for the settling out of sludge and other impurities in the oil. Other equipment includes a boiler, a steam power unit, a pump for removing the oil from the centrifuge to the settling tanks, and an optional nut cracker for extracting the palm kernel. The cost of the first Pioneer mill produced in 1939 was £1,500.[13] It had an extraction efficiency of 85 per cent and was capable of producing oil with an f.f.a. content of less than 5 per cent.

Not only did the Pioneer mill fit in with peasant small holdings and the existing organization of the industry, it also took account of Nigeria's factor proportions (*31*, p. 11):

> . . . in designing the mill no attempt has been made to render the extraction of oil and kernels completely mechanical. The stripping of the fruit bunches for the Pioneer mill is still done by hand; so, in many cases, is the separation of fibre from nuts, and of shell from the kernels. Arrangements are also made at some mills for selling back the nuts to the African womenfolk for hand-cracking. Bearing in mind that Nigeria is in the main committed—according to declared Government policy—to peasant development by non-plantation methods, there are grounds for believing that the Pioneer mill is indeed within a measurable distance of being the ideal machine for the job.

This opinion was also shared by the government. After the war, funds were provided to the Department of Commerce and Industries by the Nigeria Local Development Board to establish 12 Pioneer mills on an experimental basis. The first such mill opened in 1946. By 1949 when the regional development boards were established five mills had been brought into operation. By 1960, 145 Pioneer mills had been erected involving public investment of over £2,340,000.[14] The Pioneer Oil Mill Scheme thus ranks as one of the largest development projects undertaken by the government in the 1945–60 period.

The most recent advance in processing technology was marked by the appearance of the Stork hydraulic hand press. Designed by a Dutch company in 1959, the press was tested and ancillary equipment developed by S. C. Nwanze at WAIFOR during 1960 and 1961; extraction efficiency was found to be higher than the Pioneer mill and its capacity nearly as great (*35*). Yet the installed cost of the Stork press and its equipment (three drums for fruit sterilization, mash reheating, and oil clarification) in 1961 was only £560 against £18,000 for the Pioneer. Intended to supersede the screw press and greatly increase total palm oil production, 1,000 presses were purchases by the Eastern Nigeria govern-

[13] By 1960 the cost of an installed Pioneer oil mill was £18,000.

[14] This figure includes operational losses for Development Corporation mills in the East (96) and West (17), but not for the North (7). There are 20-odd privately owned mills in the East.

ment in 1962 under Project 31 of the 1962–68 Development Plan at a cost of £400,000.

> . . . These hydraulic presses which have an extraction efficiency of 92 per cent [86 per cent was WAIFOR's average, 95 per cent the maximum] will be sold to private entrepreneurs on a hire-purchase basis. The use of these presses will increase the output of palm oil by 30,000 tons as a result of higher efficiency. Government revenue as well as farm income will be directly increased as a result. Maintenance of the presses and technical services will be undertaken by private firms (*3*, p. 36).

Unfortunately, the planners' optimism concerning the hydraulic press was not borne out, at least in the short run. When only 31 presses had been sold by November 1963 (and of these only 10 installed) the regional Ministry of Agriculture requested W. L. Miller of the Economic Development Institute, University of Nigeria, to investigate the matter. Miller's field survey in May 1964 of 20 of the 24 presses then in operation revealed that only 8 were earning a profit and that 10 firms were not even covering variable costs (*25*). The average extraction rate was lower than the average for the Pioneer oil mills; average capacity utilization was under 30 per cent. A certain portion of the failure to achieve better results was attributable to inexperience in operating the new press, failure to reheat the macerated pulp before pressing, and inefficient labor utilization. However, the prime cause for nonprofitable operation was high fruit cost, a factor determined exogenously by competition.

Table 3 summarizes the major operational characteristics of the four technologies in use by 1963. On the basis of simple extraction efficiencies each new method should have displaced its predecessor. And, as we have seen, it has been extraction efficiency which has largely guided government policy.

In the case of the native method and the screw press, the capacity and investment vary with the size of the maceration vessel and the press—ranging from the £15 13-inch diameter type to the £40 24-inch diameter type—(*24*, p. 49). With respect to the labor force, all operations are carried out by women and

TABLE 3.—FOUR PALM OIL PROCESSING TECHNIQUES*

Technique	Date of origin	Extraction efficiency (*per cent*)[a]	Capacity (*cwt. fruit per 8 hours*)	Laborers required (*number*)	Investment required (£)
Native method	19th century	55	1–2	2	2–5
Screw press	1930	65	8–16	4	25–50
Pioneer mill	1946	85	96	22	18,000
Hydraulic hand press	1963	86	68	7	560

* Data from West African Institute for Oil Palm Research (WAIFOR), *Eleventh Annual Report* (Benin City, 1964), pp. 88–95; Anne Martin, *The Oil Palm Economy of the Ibibio Farmer* (Ibadan, 1956), pp. 12–13; W. L. Miller, "The Economics of Field Operations of the Stork Hand Hydraulic Oil Palm Press: Report to the Government of Eastern Nigeria" (Economic Development Institute, Enugu, July 31, 1964), mimeo; W. L. Miller, *An Economic Analysis of Oil Palm Fruit Processing in Eastern Nigeria* (unpublished Ph.D. thesis, Michigan State University, East Lansing, 1965), *passim*; and S. C. Nwanze, "The Economics of the Pioneer Oil Mill," *Journal of the West African Institute for Oil Palm Research,* April 1961, p. 245.

[a] Percentage of total oil content actually obtained (see text).

children in the case of the native method, while only the pressing and a small portion of the pounding are done by men in the screw press process. Women are employed to separate the nuts from the mesocarp in the Stork process, while all workers are wage-paid males in the Pioneer mills.

Extraction efficiency, shown in the second column of Table 3, is the percentage of the total oil content which is actually obtained; it can only be measured when the total oil content of the fruit being processed has been determined by laboratory analysis. These extraction efficiencies derive from tests carried out by the Research Division of the old Department of Agriculture and, since then, WAIFOR. The extraction *rate*—the form in which extraction data are usually available—is the weight of the oil actually obtained expressed as a percentage of the fruit's weight prior to extraction. If the oil content of wild palm fruit were constant, the extraction rate could be readily translated into extraction efficiency. In fact the oil content of fruit from wild and rehabilitated palm groves varies from as low as 14 per cent to as high as 25 per cent (the higher-yielding fruit tends to come from the heavier rainfall coastal areas). Thus the extraction rate achieved by the hydraulic presses surveyed by Miller ranged from 12 to 22 per cent (*25*, p. 9).

III. ECONOMIC PERFORMANCE OF ALTERNATIVE PROCESSING TECHNIQUES

Regional Distribution of Production

Before we can proceed to analyze the comparative performance of the various processing technologies, it is necessary to consider the regional distribution of palm oil production. Regional marketing board purchases of palm kernel and palm oil for 1955–65 are given in Appendix Table I. The East and the West are the major producers of kernels; on the other hand, the West supplies very little palm oil for export, and the oil that it does provide is of low quality. The North is a small export producer of both kernel and oil, the quality of the oil being primarily technical grade I. The East produces some 92 per cent of all export oil and 99 per cent of the edible ("special") grade. Thus in terms of value, the East accounts for over 95 per cent of all marketing board purchases of oil. Small tonnages of plantation oil, also of edible grade, come from the East and the West, in about equal measure; because we are interested in the peasant industry, plantation production is excluded from our analysis unless otherwise indicated.

The volume and distribution of palm oil extraction for domestic consumption is much less certain. What evidence there is suggests that in the East and North processed palm fruit is fully utilized, i.e., a conversion factor can be applied to palm kernels to determine the corresponding oil content.[15] In the West, because the oil content and quality of the dominant wild palm varieties are low,[16] and because alternative employment opportunities for men cultivating cocoa are so much more remunerative, a high proportion is not harvested, but rather left to drop and rot on the ground with only the palm kernel eventually being extracted by the women (*13*, p. 15; *33*, p. 18). Working on the assumption that

[15] For the North see 2. Fruit utilization in the East is described in the primary sources cited in footnote 1.

[16] All Pioneer mills in the West proved uneconomic for this reason. For the very low extraction rates, see *27*, p. 235. For the very small proportion of special grade oil produced, see *36*.

TABLE 4.—ESTIMATED TOTAL PALM OIL PRODUCTION AND DOMESTIC CONSUMPTION IN NIGERIA, 1961–65*
(*Thousand tons*)

Region and year		Marketing Board purchases of palm kernels	Estimated palm oil production	Marketing Board purchases of palm oil	Residual domestic consumption
East	1961	208.5	271.0	160.7	110.3
	1962	169.0	219.7	120.9	98.8
	1963	197.0	256.1	139.4	116.7
	1964	203.0	263.9	138.9	125.0
	1965	221.0	287.3	153.6	133.7
West	1961	200.9	70.3	12.4	57.9
	1962	173.9	60.9	7.7	53.2
	1963	197.7	69.2	9.6	59.6
	1964	184.0	64.4	9.0	55.4
	1965	203.0	71.1	10.6	60.5
North	1961	20.8	25.0	.4	24.6
	1962	19.3	23.2	—	23.2
	1963	18.3	22.0	—	22.0
	1964	15.0	18.0	—	18.0
	1965	25.0	30.0	—	30.0
Total	1961	430.2	366.3	173.5	192.8
	1962	362.2	303.8	128.6	175.2
	1963	413.0	347.3	149.0	198.3
	1964	402.0	346.3	147.9	198.4
	1965	449.0	388.4	164.2	224.2

* Marketing Board purchases are from Appendix Table I, and include small amounts of plantation oil. Estimated total palm oil production is based on the assumption that in the East and North all palm fruit associated with the palm kernels sold to the Board is used for oil, and that in the West only one-third is used for oil (see text). Conversion factors applied to purchased kernels are as follows: East 1.30, West .35 (i.e., 1.05 ÷ 3), and North 1.20. The relationships between palm oil and palm kernels are derived from United Africa Company, *Statistical and Economic Review,* March 1954, pp. 3, 16, 18, 19.

only one-third of the fruit that provides kernels is processed for oil in the West, we arrive at the estimates of total palm oil production and domestic consumption shown in Table 4.

Annual production of palm oil for the three most recent years considered ranges from 347 to 388 thousand tons, with internal consumption ranging from 181 to 224 thousand tons. These figures are consistent with the Eastern Nigeria Ministry of Agriculture's standing estimate of 200,000 tons of palm oil consumed domestically. However, it must be admitted that all estimates of total production are to a certain extent guesswork; in our case the "guess" is the one-third utilization factor for the West.[17]

For the purpose of determining output shares of the four processing technologies, we shall confine our attention to the East, where production estimates are the most reliable and where some data about processing are available. The

[17] Based on the assumption that 40 to 50 thousand tons is a reasonable consumption figure for the West. A significant but unknown share of internal production in the East is exported to the North.

total production of oil during 1961–64 by ENDC Pioneer mills ranged between 15,200 and 17,000 tons; it is estimated that oil production of the private Pioneer mills did not exceed 9,000 tons and was probably a good deal less.[18] In 1963 production by the hydraulic presses was negligible; in 1964 it was about 480 tons (*24*, p. 73). Thus, in 1964 the native method and the screw press, technologically the least efficient processes, accounted for 239,000 tons or 91 per cent of the total oil processed.

The breakdown of output between the native method and the screw press is highly problematic. W. L. Miller's sample survey of 47 screw presses in two locations gave an annual average output of 6.2 tons per press; estimates of the number of screw presses in operation in the East range from the Ministry of Agriculture's enumerated 3,900 to Miller's population-based estimate of 17,600. Combining the average output figure with the two extreme values for the number of screw presses yields 24,000 tons by screw press and 215,000 tons by native method as the lower limit, and 109,000 tons by screw press and 130,000 tons by native method as the upper limit. In the only two empirical case studies in the North and the West, it was reported that processing was primarily by the native method (*30*, p. 46; *2*). Thus, available evidence seems to suggest that the native method continues to be the predominant technology employed in palm oil extraction throughout Nigeria.

We will begin our examination of the Pioneer oil mill's performance by scrutinizing its role in the spectacular improvement in the quality of Nigerian palm oil which occurred during the period that the mills were being introduced. In 1950 less than .5 per cent (300 tons) of the oil purchased by the marketing board was of Special Grade quality (f.f.a. content of 4.5 per cent or less); by 1955 Special Grade oil accounted for about 70 per cent (129,300 tons) of marketing purchases (Appendix Table I). It is commonly claimed that the Pioneer oil mills, in conjunction with the price differentials, played an important part in bringing about this qualitative "revolution."[19] That such is demonstrably not the case can be seen from a comparison of Special Grade oil purchased in the Eastern Region and the quantity of such oil produced by ENDC's Pioneer mills, the latter being responsible for the great bulk of all centrifuged Special Grade oil.

At no time between 1950 and 1960 did ENDC own less than three-quarters of all operating Pioneer mills; allowing a 50 per cent or even 100 per cent increase on the ENDC figures it is clear that the Pioneer mill's contribution to the transformation in the quality of Nigerian oil has been negligible (Table 5).

Since the bulk of Special Grade oil has not been produced by the Pioneer mills, it must have been processed by traditional methods or by the screw press. Most of the pre-1950 students of the palm oil industry had asserted, like Richenda Scott, that such an outcome was highly improbable (*29*, p. 242):

> . . . it is doubtful if the African producer, utilizing the fruit of the wild palm, will ever suceed in obtaining an oil of a low f.f.a. content on any large scale, or will be able to maintain that standard over a long period by his present crude methods, even with the assistance of the handpress.

[18] Interview with the Chief Engineer, Pioneer Oil Mill Scheme, Aba, September 1964.

[19] Major references include *7*; *11*; *17*, p. 120; *23*; *27*, p. 233; *29*, p. 242; *31*, p. 3 (but recanted in *33*, p. 5).

TABLE 5.—TOTAL PURCHASES OF SPECIAL GRADE PALM OIL AND TOTAL OUTPUT OF EASTERN NIGERIA DEVELOPMENT CORPORATION (ENDC) PIONEER MILLS, SELECTED YEARS, 1950–63*

(Tons)

Year	Special grade oil	
	Total purchases[a]	ENDC Pioneer output
1950	300	300
1951	8,500	700
1952	52,900	4,700
1953	106,800	7,300
1954	124,185	7,400
1955	128,797	15,600
1957	117,133	14,300
1959	135,286	16,300
1961	127,703	14,100
1963	114,000	15,400

* Data from Nigeria Oil Palm Produce Marketing Board, and Eastern Nigeria Marketing Board, *Annual Report*, various issues; and from information supplied by the Chief Engineer, Pioneer Oil Mill Scheme, Aba.

[a] Figures for 1950–54 include small amounts (maximum 1,000 tons) from West and North; thereafter figures are for the East only.

This opinion seems to have carried forward, despite proof to the contrary, to much of current literature, including ENDC and other government publications. That the f.f.a. content was solely dependent upon the extent of fermentation, i.e., the speed and care of bringing the fruit to the point of processing, and that the latter could be held to a minimum with the improved "soft oil" process had already been established by the late 1920's by research officers in the Department of Agriculture (*21*). Indeed, experiments conducted in 1963 by T. N. Okwelogu, Chemist of the Eastern Nigeria Marketing Board, suggest that traditional methods, unaided by the screw press, are capable of producing a higher quality oil than any of the mechanically-assisted processes.[20]

All available information, then, would seem to indicate that it was the price incentive alone which brought about the qualitative transformation of Nigerian palm oil. Evidence, so far unnoticed, that traditional methods were capable of such achievement is provided by the 1944–49 period when new gradings and increased price differentials were introduced.[21] Over the decade 1939–49 the average f.f.a. content of Nigerian palm oil dropped from about 25 to 14 per cent.[22] Table 6 shows the response to price differentials for both the earlier and later periods.

[20] Information supplied by the Eastern Nigeria Marketing Board. Technical factors responsible for the potentially lower f.f.a. content of oil produced by nonmechanical means are a lesser degree of heat generated in the extraction process and the absence of contact with oxidizing metals.

[21] During the 1920's and 1930's the writer has been able to find references to only two grades of oil, soft and semihard (e.g., *Blue Book*, section 121); 18 per cent f.f.a. seems to have been the dividing line. For later classification see Table 6, note *a*.

[22] Figures for the years 1940–45 are not available. Calculated on the basis of .5 per cent less than the maximum (owing to the middlemen's practice of "mixing") and 45 per cent for the "over 36 per cent" category.

TABLE 6.—MARKETING BOARD PURCHASES OF PALM OIL IN NIGERIA, CLASSIFIED BY FREE-FATTY-ACID (f.f.a) CONTENT, COMPARED WITH PRODUCER PRICES, SPECIFIED YEARS, 1939–54*

Approximate f.f.a. content (*per cent*)[a]		Per cent of purchases					Producer prices per ton			
							1949		1954	
		1939	1946	1949	1951	1954	£	*s.*	£	*s.*
Under	4.5				6	61			61	—
4.5	9	20	56	66	71	30	42	15	46	—
10	18	34	18	15	11	4	37	2	34	—
19	27	13	16	13	8	5	33	—	29	—
28	36	14	9	6	4	—	...		...	
Over	36	19	1	—	—	—	...		—	—

* Data from United Africa Company, *Statistical and Economic Review*, March 1948, p. 28; *ibid.*, March 1954, p. 10; Great Britain, Commonwealth Economic Committee, *Vegetable Oil and Oilseeds* (London, 1949 and 1955); and Nigeria, Federal Office of Statistics, *Annual Abstract of Statistics* (Lagos, 1960), p. 64.

[a] Content specified in 1950; f.f.a. content classifications were actually as follows in other years (*per cent*):

1944–49	1950
0 – 9	0 – 4.5 (3.5 from 1956)
10 – 18	4.5 – 9
19 – 27	10 – 18
28 – 36	19 – 27 (30 from 1953)
Over 36	28 – 36 (not bought after 1951)

The more rapid rate of improvement in oil quality after 1950 is probably attributable to the exaggerated differentials (5 to 12 times greater) paid by the marketing board relative to the premia given in the free market.[23] This has been possible only because the marketing board has set producer prices well below world prices—with its dampening effects on total supply. Total proceeds to Nigeria from palm oil exports would undoubtedly have grown faster under a regime of higher producer prices and smaller differentials.

Why has the Pioneer oil mill, with an extraction efficiency of 85 per cent, been unable to sweep aside preexisting techniques which attain only 55 to 65 per cent efficiency? Why have the ENDC Pioneer mills produced at only two-fifths of their capacity? Why have a large number of the Pioneer mills gone out of operation altogether? Part of the answers to these questions was uncovered by S. C. Nwanze, then WAIFOR's industrial engineer, in an investigation into the economics of the Pioneer mills carried out in 1959 and 1960 (*27*). Mr. Nwanze identified two groups of factors responsible for the disappointing performance, the first related to technical efficiency and management organization and the second to the supply of fruit.

Regarding the supply of fruit, Nwanze noted the seasonality of wild palm fruit yields; the peak harvesting season occurs between February and June and the supply of fruit tapers off during the latter six months of the year. Where roads are poor, the fruit supply is adversely affected during the early rains because farmers will commonly only undertake to carry fruit to the mills when they are in especial need of money. Competition from hand press operators,

[23] In 1954 the premium paid in the Liverpool market for every 1 per cent lower f.f.a. content was 3*s*. 6*d*. per ton; the corresponding premium over the interval between the marketing board's Special Grade and Grade I was 60*s*.; by 1964 it had been reduced to 22*s*. (*33*, p. 12).

who show considerable initiative in fruit collection, also restricts the supply to the mills. Finally, the opposition of the women to having to give up their traditional right to the palm kernels has caused the men in some areas not to sell their fruit to the mill.

Underlying all the contributing causes identified by Nwanze is the fruit price that each processor is able to pay; this depends upon the extraction efficiency of the processor's technology, the combined labor and capital processing costs, and the price received for the end products—the oil and kernels. Nwanze's principal contribution is an analysis of the intra-firm technical and organizational factors that are important in determining the Pioneer oil mill's processing cost per unit of output.

Mr. Nwanze describes the faults in design as follows (*27*, p. 234):

> . . . A low installed cost and cheapness of labour were emphasized in the design of the mill and individual equipment conforms to a good but rather rugged standard of mechanical design. It is unfortunate, however, that when all the equipment is assembled the mill does not provide an example of a design giving smooth and unhindered processing. The most important item, which determines the throughput of the mill, is the centrifuge, and all ancillary vessels or machinery might better have been made of the correct size to suit the centrifuge capacity and so prevent bottlenecks in the process. For instance, even when fruit is available, the centrifuge may remain idle because the autoclave and the digester are not producing sufficient fruit to feed it continuously. On the other hand, it is not unusual to find a big pile of fibre still to be separated, because the nut separator cannot deal quickly enough with fibre coming from the centrifuge.
>
> Some of the equipment appears to have been "borrowed" from other industries without much modification. The fibre separator resembles a cotton ginning machine, the sludge tank and the clarification tanks are reminiscent of the sugar industry, and the digester, which looks like a soap blending pot, has not been steam jacketed in spite of the need for heat to assist in the rupture of oil cells during fruit maceration. The centrifuge is uncovered and considerable heat loss is unavoidable when the basket is spinning. Flow of materials through the various stages of the process is also impeded. The equipment in the mill could have been arranged to make the maximum use of gravity in assisting the flow of materials. A vertical construction would have made the mill more compact and also would have reduced labour since about half of the hands employed do nothing but carrying.

More important than design shortcomings were failings in management organization, especially labor utilization. The investigator's time studies showed that only 7 to 14 per cent of total workable man-hours were usefully employed (*27*, pp. 238–40). Failure to coordinate the size of the labor force, raw material supplies, and oil evacuation resulted in prolonged stoppages. Supervisors failed to exercise their responsibilities and were often ill-informed about processing technology. There was little rhythm of work, work methods were often inefficient, and many supposedly skilled operators had but a vague understanding of their job. Finally, low levels of maintenance led to frequent breakdowns.

Having diagnosed the difficulties, Mr. Nwanze went on to demonstrate the consequences of applying a few simple principles of industrial engineering. Taking a standard Pioneer mill, he reduced the labor force from 29 to 22, increased fruit throughput from 18.5 to 22 centrifuge charges per shift, and obtained a 20 per cent higher extraction rate (by reducing heat loss from the centrifuge) per unit of fruit processed (*27*, pp. 250–51). Taken together these improvements yielded a 96 per cent increase in output per man. The potential effect of Mr. Nwanze's innovations was to reduce processing cost by a third; however, he calculated that the mills were not an economic proposition unless they achieved an 18 per cent oil extraction rate and operated at a minimum of 67 per cent capacity utilization, i.e., 2,000 tons of fruit per year per mill (*27*, p. 247).

Now let us look at the actual performance. The average oil extraction rate for at least 12 of the 17 mills in the Western Region in 1954 was 12 per cent; by 1957, 14 mills had been closed down. Extraction rates achieved by mills in the East have ranged from 21.5 to 14 per cent. Regarding the volume of fruit processed, if we take the aggregate annual average for ENDC mills, we see that the scheme has never achieved Nwanze's threshold of economic operation, either in processing capacity utilized or the extraction rate (Table 7).[24] By 1964 ENDC had closed down 29 of its 96 mills; of the remaining 67, 15 were not earning a surplus over direct costs. Only three were still running in the North and these at a loss (*19*, p. 259). Some 20-odd privately operated mills (mostly former ENDC mills purchased by the major palm produce buyers) were faring slightly better than their more favorably located publicly owned competitors, largely owing to their greater efforts at fruit collection.[25]

TABLE 7.—PERFORMANCE OF ENDC PIONEER OIL MILLS, 1952–64*

Year	Number of mills	Fruit capacity[a] (*tons*)	Fruit milled (*tons*)	Capacity utilized (*per cent*)	Extraction rate (*per cent*)
1952	52	156,000	20,646	13	16.8
1953	53	159,000	42,668	27	17.1
1954	70	210,000	47,317	23	16.7
1955	86	258,000	100,051	39	17.5
1956	93	279,000	98,042	35	17.2
1957	95	285,000	102,991	36	17.0
1958	96	288,000	114,784	40	17.1
1959	96	288,000	105,403	37	17.3
1960	95	285,000	121,681	43	17.1
1961	95	285,000	94,682	33	16.8
1962	82	246,000	96,251	40	16.8
1963	78	234,000	101,569	43	16.5
1964	67	201,000	96,371	48	17.2

* Data supplied by the Chief Engineer of the Pioneer Oil Mill Scheme in an interview at Aba, September 1964.

[a] At 3,000 tons per mill per year; or 625 eight-hour shifts at 4.8 tons per shift. This involves triple shifts during part of the peak season. (See *27*, pp. 244–45.)

[24] Modest paper profits were received in 1955–56, 1958–59, and 1959–60 as a result of underestimating depreciation and omitting administrative overheads. Helleiner (*17*, p. 119) reports cumulative losses of £378,400 as of March 1962.

[25] Interview with the Chief Engineer, Pioneer Oil Mill Scheme, Aba, September 1964.

TABLE 8.—AVERAGE OPERATIONAL DATA, PER HUNDREDWEIGHT OF OIL PRODUCED FOR FOUR PROCESSING TECHNOLOGIES, 1964*

Item	Native method	Screw press	Stork hydraulic press	Pioneer oil mill
Fruit required (*cwt.*)	6.5	6.6	6.3	5.8
Total labor (*man-days*)[a]	9	3.8	3	1.1
Direct labor cost (*s./d.*)	—	—	7/2	3/4
Indirect labor cost (*s./d.*)	—	—	2/10	2/4
Depreciation and repair (*s./d.*)	—/10	1/—	3/10	8/3
Oil revenue (*s./d.*)	31/9	32/—	38/—	38/1
Nut revenue (*s./d.*)	14/4	15/—	13/2	13/2
Total revenue (*s./d.*)	46/1	47/—	51/2	51/3
Number of farms surveyed	67	47	20	67
Average annual oil output per processor (*tons*)	.4	6.2	20	248

* Data from W. L. Miller, *An Economic Analysis of Oil Palm Fruit Processing in Eastern Nigeria* (unpublished Ph.D. thesis, Michigan State University, East Lansing, 1965), pp. 37, 39, 40, 43, 44, 50–57, 78, 80, 82.
[a] One man-day is equal to 8 man-hours, or 8 woman-hours, or 32 child-hours.

IV. AN EXPLANATORY HYPOTHESIS

What is to explain the competitive superiority of the technologically inferior techniques—an outcome which results in the loss of some 30 per cent of potential production? Is it only a question of managerial and technical slack in the operation of the Pioneer mills and hydraulic presses, or is it something more fundamental? The explanation to be developed in what follows is that two factors in addition to organizational inefficiency—the small scale of the more primitive processes and the availability of household labor—are responsible for thwarting the introduction of more advanced technology.

Our starting point is the budget studies of Miller carried out in 1964. His findings are summarized in Table 8. Only in the case of wages did Miller depart from reporting actual figures. In this instance he substituted "standard" wages (3*s.* per day for male workers, 1*s.* 6*d.* per day for female) "because the primary objective [of this study] is to compare the five different processing technologies" (*24,* p. 40).[26] We have discarded his imputed labor costs for the native method and screw press because these were in fact operated by unpaid family labor. For the privately operated stork presses the 3*s.* male wage rate is a representative average (range, 2*s.* 7*d.* to 3*s.* 6*d.*); however, in the case of the Pioneer mills the basic wage is in fact 5*s.* Indirect labor rates—managerial and skilled maintenance—were estimated at realistic levels.

In terms of the human input, the native method is very inefficient (largely because of the time required at the extraction stage) and the Pioneer mill is very efficient (owing to the mechanization of the maceration stage). The combined labor-capital cost per cwt. of oil for the Stork hydraulic and Pioneer mill are

[26] As a result of using standard money wages—and in general averaging widely differing price relationships into a single constant—Miller's pioneering empirical study is in many respects more nearly a technological than an economic analysis. The fifth technology considered by Miller is a large-scale plantation factory.

virtually identical at 13*s.* 10*d.* and 13*s.* 11*d.*, respectively. For the native method total annual depreciation is but 5*s.* and, as the items are also used as household utensils, there may be some question as to whether the decision-makers impute any capital costs at all to processing. The 13*s.* cost advantage of the native and screw press techniques is partially offset by higher fruit costs and lower total revenue. The latter reflects the absence of a final stage of clarification and bulking in eight-hundredweight metal drums. After allowing for a revenue differential of 5*s.* and the purchase of an additional .8 cwt. of fruit (see Table 8, first row) at 6*s.* per cwt., the native method and screw press processors are left with a surplus or competitive advantage over the most efficient technology of 3*s.* 3*d.* per cwt. of oil processed.

The introduction of transport costs provides a further, although modest, advantage to the more numerous small-scale processors. Given a weight reduction of about 50 per cent between palm fruit on the one hand, and its extracted oil and nut constituents on the other, there is a transport savings to be earned by processing the fruit as near as possible to the locus of harvesting. The larger the capacity of the processor, the greater the radius over which he must attract fruit. Between the smallest-scale native method and the largest-scale Pioneer mill, Miller reports a differential of 13*d.* in fruit assembly cost per cwt. of oil produced. If the Pioneer mill were to operate at full capacity the additional fruit assembly cost (from 23*d.* to 33*d.*) would be more than counterbalanced by the reduction in fixed costs (*24,* Chap. III).

The raw material requirement (the reciprocal of the extraction rate), shown in the first row of Table 8, is the largest cost item at 6*s.* per cwt. of fruit. Surprisingly (and seemingly unaccountably) the average extractive performance of the native method was slightly greater than that of the screw press (15.4 per cent as against 15.2 per cent). If average oil content is put at 20 per cent—the conventional aggregate average for the East—the Pioneer extraction rate of 17.2 per cent represents an extraction efficiency of 86 per cent and the 15.2 per cent of the screw press technique is equal to a 76 per cent extraction efficiency.

The apparent discrepancy between this recorded performance differential and the 85 to 65 per cent test differential reported by WAIFOR is in fact a reflection of the small-scale operator's advantage in obtaining fruit of higher oil content. Not only is the small-scale processor able to inspect the small quantity of fruit he buys much more carefully than his larger competitors, but with no fixed costs he can stop production whenever the better quality fruit is not available. This logical presupposition is supported by all investigators' reports that the small-scale processors do get the premium fruit, and by Miller's findings that these two small-scale technologies have more than doubled the unutilized capacity of the other two techniques (*24,* p. 94).

Regarding the labor input, there would seem to be little doubt that in the case of the native method, labor time is virtually costless. Miller's studies show that the combined labor time of women and children spent on processing per day ranges between one and two hours (*24,* p. 46).[27] Fitted in between household and farming chores, the time devoted to palm fruit is otherwise "free time"

[27] Four child-hours equal one woman-hour equals one man-hour.

TABLE 9.—AVERAGE LABOR REQUIREMENTS PER HUNDREDWEIGHT OF OIL EXTRACTED BY THE SCREW PRESS*

Item	Abak		Okigwi	
	Female	Male	Female	Male
Days of 8 hours per cwt. oil				
Sterilization	1.4	—	.4	.2
Pounding	.4	.4	.4	.3
Pressing	.2	.3	—	.2
Separation of nut	1.4	—	1.6	—
Second pressing	.1	.1	—	.1
Total	3.5	.8	2.4	.8
Average production per 8-hour day (*cwt.*)	1		2	
Days in operation per annum	60		94	
Number of firms surveyed	21		26	

* Data from W. L. Miller, *An Economic Analysis of Oil Palm Fruit Processing in Eastern Nigeria* (unpublished Ph.D. thesis, Michigan State University, East Lansing, 1965), pp. 51, 61.

and does not involve any sacrifice of remunerative employment in another activity. As the wife, in many cases, traditionally receives the kernel-containing nut as payment for her labor, she is quite happy to forego her leisure. Indeed, the intra-family income redistribution effect of selling fruit rather than its processed constituent parts gave rise to the much publicized female boycotts and demonstrations against Pioneer mills in the early 1950's.

In the case of the screw press, the amount of time per day devoted to processing is substantial and involves male labor. The data in Table 9, from Miller's survey, show both the amount of labor expended per cwt. of oil and its distribution among the various stages of processing.

In his report on screw press production in Abak and Okigwi, Miller observes that "since most workers were members of the family they were not paid wages for their labour" (*24*, p. 52); but in at least two provinces, Annang and Uyo, the workers are commercially engaged, receiving 40 per cent of the processing fee (*28*, p. 61). In this instance the screw press owner does not buy the fruit, but merely expresses the oil for a fixed charge; if the proprietor of the screw press is a middleman, he will then buy the oil from its owner. In either case—whether receiving a money wage or not—it is clear from the combined hours of labor time expended per day (34 hours in Abak and 51 in Okigwi) that substantial alternative employment opportunities are being sacrificed and that consequently a real wage is imputed to labor in the case of the screw press technology.

Given the differentials in the valuation placed on labor, the ordinal ranking of the two technologies as calculated from Table 8 is altered. The native method is now seen to have a clear competitive advantage over the screw press. Lending support to this conclusion, Miller reports a net reduction in the number of screw presses (*24*, p. 104):[28]

[28] Miller interprets this trend as applying to all processing technologies since, with his imputed wage values, the native method emerged as the least efficient technique. On the basis of his calculations, for all techniques average revenue was less than average cost.

> . . . Between 1960 and 1964 this [expansionary] trend [in the number of operational screw presses] 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 had changed from manufacturing presses to manufacturing bed frames.

The preceding analysis can be formalized into a simple algebraic expression which has general validity for the determination of competitive superiority among differing processing technologies where the prices and quality of the factor inputs are variable as between technologies.

The advantages of the modern, advanced technologies are typically a higher extraction efficiency (more final product per unit of raw material input) and a smaller labor requirement (man-hours) per unit of final product. The countervailing advantages of the primitive technique(s) stem from its small scale. The first is very low wage rates (approaching zero in the limiting case) owing to the availability of household labor with little or no opportunity cost. The second advantage of the primitive technology is its ability to command the best quality raw material input by virtue of (a) costless shutdown when the best quality is not available, (b) more thorough inspection of the raw material purchased, and (c) greater local knowledge and contacts. The instance of raw material advantage is but one case of the advantage of costless shutdown and startup when any condition of production is variable, i.e., intertemporal variation in any item of cost or revenue.

The following symbols are used in the algebraic formulation:

C = Cost per unit of output
L = Labor cost per unit of output
K = Capital consumption and repairs per unit of output
P_a = Price per unit of output of the advanced technology

Subscript a = Advanced technology
Subscript p = Primitive technology

T = Technology
S = Scale of production
r = Extraction rate
t = Transport cost per unit of output
$Z = P_a - P_p$ The difference between the revenue per unit of output of the advanced and primitive technologies, i.e., the quality differential

General relationships:

$$C = f(L, K, t, 1/r)$$
$$L = f(S, 1/K)$$
$$K = f(T)$$
$$t = f(S)$$
$$r = f(T)$$

The advanced technology will be able to bid the raw material supply away from the primitive technique when $C_a < C_p + Z$, which occurs when

$$\frac{r_a - r_p}{r_p} \cdot P_a > (L_a - L_p) + (K_a - K_p) + (t_a - t_p) - Z\,.$$

Conversely the primitive technology will predominate when $C_a > C_p + Z$, which occurs when

$$\frac{r_a - r_p}{r_p} \cdot P_a < (L_a - L_p) + (K_a - K_p) + (t_a - t_p) - Z\,.$$

In the case of palm oil, given the level of producer prices, the value of the incremental output achieved by the Pioneer oil mills and the Stork hydraulic presses has not been equal to the incremental costs entailed, relative to the more primitive native method and screw press techniques.

V. ECONOMIC EFFICIENCY: AN OPTIMAL SOLUTION

The existing situation of palm oil processing in Nigeria results in the loss to the economy—both with regard to export earnings and domestic consumption—of thousands of tons of palm oil left in the discarded fruit pulp each year. The loss is equal to the maximum obtainable extraction efficiency (say 85 per cent) less the weighted average actually achieved by the combined technologies (say a generous 70 per cent) as a ratio of the latter, times the total oil produced. If the actual production in the East was 287,000 tons in 1965, the recoverable oil lost to the economy was 61,000 tons—worth over £5 million at the 1965 export f.o.b. price.

There is another cost to the economy, an unmeasurable social cost, involved in the use of household labor, particularly that of the housewife. Over the long run a sociocultural transformation involving individual behavioral patterns, motivation, and attitudes must accompany or perhaps precede economic growth. A very important factor concerns changes in the pattern of child-rearing. The appropriate education of the mother is half of the matter; release for both her and her children from the long hours of stultifying drudgery involved in processing activities (including preparation of gari) is the other half.

The remedy to both these losses lies in the marketing board's producer price policy. As shown in Table 10, producer prices have consistently been set well

TABLE 10.—PRICES OF EDIBLE GRADE PALM OIL TO PRODUCERS AND FOR EXPORT, 1956–64*
(*£ per ton*)

Year	Producer price at Port Harcourt	Export price f.o.b.
1956	50.0	82.38
1957	50.0	86.02
1958	50.0	75.21
1959	47.75	76.55
1960	47.75	73.85
1961	47.75	82.72
1962	40.0	75.88
1963	40.0	75.31
1964	41.0	80.78
1965	41.0	90.00

* Data from Great Britain, Commonwealth Economic Committee, *Tropical Products Quarterly*, various issues; Nigeria, Federal Office of Statistics [early years issued by Department of Statistics], *Nigeria Trade Summary*, various issues; and Nigeria, Federal Office of Statistics, *Economic Indicators*, March 1966.

below world prices; this has been done not for reasons of price stabilization but rather as a means of augmenting public savings (*18,* p. 582 ff.).

There are two ways the marketing board can assure that all palm produce is processed by the most efficient technologies. The first is by paying a higher price for oil extracted by Pioneer mills and Stork presses relative to that paid for oil extracted by the native method and screw press. The amount of this "subsidy" or preferential tax relief would have to be greater than the adjusted cost differential of these two technologies, say 5*s.* for cost equalization and a 2*s.* competitive margin.

The second method, which, unlike the first, would not require any policing or be open to administrative incompetence or abuse, would be for the marketing board to raise the producer price for palm oil to that level at which the value of the incremental output of the advanced techniques exceeds the adjusted incremental cost. At this point, the advanced technologies could bid away the fruit from the more primitive processors. This required producer price (P_a) can be determined from the earlier formula. At equilibrium where neither technology is at an advantage,

$$\frac{r_a - r_p}{r_p} \cdot P_a = (L_a - L_p) + (K_a - K_p) + (t_a - t_p) - Z\,.$$

If P_a is raised, T_a will tend to prevail; if P_a is lowered, T_p will tend to prevail.

From Table 8, $r_a = .17$ and $r_p = .15$; using a 5*s.* wage rate, the right-hand term of the equation can be estimated at about 10*s.* Then $.133 \times P = 10s.$, $P_a = 75s.$ Allowing another 3*s.* per cwt. of oil for transport and handling to Port Harcourt (the point at which the producer price is calculated) and 2*s.* as the competitive margin to be paid in higher fruit prices, we arrive at 80*s.* per cwt. of palm oil (or £80 per ton) as the price required to insure that the bulk of palm oil will be processed by Pioneer mills and Stork presses.

Should it be established that the public savings foregone by a reduced tax burden on palm oil is more beneficial to the economy's growth than the incentive effects of a higher price on palm grove rehabilitation and increased fruit collection, the producer price can be lowered to its previous level once the Pioneer mills and Stork presses have become dominant. This felicitous result is explained by a rising average extraction rate achieved by the two advanced technologies as the better quality fruit comes to them. Owing to their improved extraction rate, the processors can now raise their price for fruit as a proportion of the palm oil price—to such an extent that, above a certain equilibrium threshold, they can pay more for the fruit than the primitive processors can realize from sale of their final products.

The equilibrium threshold producer price can be determined by the same formula as before; the only difference is that now the term $(r_a - r_p)/r_p$ is considerably larger. If we assume that both technologies now get the same quality fruit, their extraction rates stand in the same proportion as their extraction efficiencies $(.85 - .65)/.65 = .310$. The incremental output of the advanced technology relative to the primitive techniques is now more than double the initial .133. Substituting the new value we get $.310 \times P = 10s.$, or $P = 32s.$ If we add our earlier 5*s.* mark-up to cover transport and a competitive advantage margin, we arrive at a minimum producer price of 37*s.* per cwt. of oil (£37 per ton) at which the Pioneer mills and Stork presses would still be able to bid away the raw material supply.

In presenting an explanation for the observed output shares of the various technologies and a proposed optimal solution in the preceding pages, we have implicitly assumed that homogeneous conditions exist throughout the palm industry. In fact, there may be considerable geographic variation in (a) the division of labor within the family by sex, (b) patterns of labor as required by differing food crops and cultivation practices, and (c) local customs concerning palm fruit harvesting and processing. All of these factors, by denying the farmer certain choices, might qualify our analysis for these particular areas. In aggregate, however, such variations are unlikely to modify significantly the workings of the underlying economic relationships. Nevertheless, this is an important area for further empirical research. As to the values we have assigned our parameters, by assuming that processing costs will fall only by 10*d.* as a result of full capacity operation of the advanced technology (it could be as high as 3*s.*), and by using the extraction efficiency of the screw press and the zero labor cost of the native method, we have biased our result in favor of the primitive technology. This enhances the probability that the solution proposed—raising the producer price to £80—will be an efficient one.

Let us sum up the benefits and costs of the policy that has been proposed, considering the situation after the fruit supply has been bid away by the advanced technology and the producer price has been returned to its 1965 level of 41*s.* per cwt. The total output of palm oil has been increased by a minimum of 20 per cent.[29] Farm household labor time has been freed with no reduction in real income: the value of the 31 per cent additional oil obtained by the Stork and Pioneer processors allows them to pay as much to the farmer for his raw fruit as he could previously get for an equivalent amount of oil and nut.[30] Primary production and fruit gathering are likely to be stimulated as the returns per unit of labor time have increased, *a fortiori* with a rise in producer prices. Even with no change in primary production or fruit collection, tax revenues are augmented in proportion to the advance in the average oil extraction efficiency.

Although there is less certainty about the rate of return to capital in alternative uses, the writer would argue that since most Development Corporation investments are earning negative returns, no more profitable or socially productive investment would be sacrificed as a result of public investment in palm oil processing. For some of the private investment, the existence of the profitable opportunity with its comparatively low capital threshold would induce savings and capital formation that would not otherwise occur; in any case, the private investment will not take place if more remunerative alternatives exist. Lastly, there are two external economies: freeing the housewife and her children from the stultifying drudgery of processing activities as a necessary condition for desirable

[29] That is, the average extraction efficiency has increased from a maximum of 70 to 85 per cent. There is also likely to be an output effect, i.e., increased fruit collection, which would lead to a further expansion in palm oil production.

[30] Taking 38*s.* as the processor's revenue per cwt. of oil, 31 per cent is 11.8*s.*; combined with the 5*s.* quality premium, the differential revenue available to cover the entire cost of processing by the advanced technology is 16.8*s.*

changes in child-rearing patterns, and the dynamic educative effects of introducing modern technology and organizational skills into the heart of the traditional economy.

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Appendix Table I.—Purchases of Palm Products by Regional Marketing Boards in Nigeria, 1955–65*
(Tons)

A. Palm Oil by Region or Type of Holding

Year	East	West	North	Small–holder	Plantation	Total
1955	165,169	22,174	3,280	184,691	5,932	190,623
1956	161,876	18,934	3,521	177,967	6,364	184,331
1957	153,651	15,527	1,934	165,788	5,324	171,112
1958	167,052	15,398	1,905	177,611	6,744	184,355
1959	170,067	18,818	1,358	182,865	7,378	190,243
1960	170,003	19,129	973	183,078	7,027	190,105
1961	160,693	12,370	370	164,635	8,798	173,433
1962	120,884	7,661	—	120,600	7,900	128,545
1963	139,412	9,619	—	139,700	9,400	149,031
1964	138,900	9,000	—	138,700	9,200	147,900
1965	153,600	10,600	—	153,500	10,700	164,200

B. Small Holder Palm Oil by Region and Grade

Year	East			West			North		
	Special grade	Grade I	Grades II–III	Special grade	Grade I	Grades II–III	Special grade	Grade I	Grades II–III
1955	128,485	33,207	622	340	7,289	11,468	511	2,769	—
1956	128,162	30,310	162	413	5,774	9,625	619	2,902	—
1957	117,133	34,129	91	384	5,283	6,834	483	1,451	—
1958	137,109	26,549	121	358	5,446	6,121	186	1,719	—
1959	135,286	30,463	941	808	7,668	6,341	208	1,150	—
1960	132,952	33,492	460	939	8,528	5,734	381	592	—
1961	127,703	28,144	183	1,312	3,844	3,079	361	9	—
1962	99,100	17,100	300	1,200	900	1,900	—	—	—
1963	114,700	19,100	400	1,800	1,600	2,100	—	—	—
1964	109,000	24,200	200	2,400	1,500	1,400	—	—	—
1965	112,400	34,800	200	2,800	2,100	1,400	—	—	—

C. Palm Kernels by Region

Year	East	West	North	Total
1955	194,904	204,280	14,467	413,651
1956	211,202	231,612	14,219	457,033
1957	201,611	191,954	13,013	406,578
1958	211,024	225,990	18,331	455,345
1959	211,558	197,574	18,731	427,863
1960	208,173	196,680	18,364	423,217
1961	208,483	200,940	20,806	430,229
1962	168,953	173,878	19,318	362,149
1963	197,048	197,695	18,317	413,060
1964	203,000	184,000	15,000	401,000
1965	221,000	203,000	25,000	449,000

* Data from Nigeria, Federal Office of Statistics, *Annual Abstract of Statistics, 1964*; Great Britain, Commonwealth Economic Committee, *Vegetable Oils and Oilseeds, 1965*, pp. 136–37, and its *Tropical Products Quarterly*, March 1965, and June 1966; and G. K. Helleiner, *Peasant Agriculture, Government, and Economic Growth in Nigeria* (Homewood, Illinois, 1966), Table II-A-5.