TECHNOLOGY CHOICE IN INDUSTRY
A STUDY OF GRAIN-MILLING TECHNIQUES IN TANZANIA

By

M.S.D. Bagachwa
University of Dar es Salaam
Tanzania

JULY 1988

TECHNOLOGY CHOICE IN INDUSTRY: A STUDY OF GRAIN-MILLING TECHNIQUES IN TANZANIA

1. The Problem

For the past decade and half, the technological choice question has assumed an important role in the economic development literature. The interest in the subject stems mainly from the concern with providing employment to growing labour force in the less developed countries (LDCs). In particular, there has been a growing disenchantment with the past industrial policies pursued in the LDCs. It is contented that, in the first place, many of the industrial production processes employed have been inappropriate relative to the societies' stock of knowledge and existing resources. And, secondly, that most of the industrialization effort has gone into large towns and cities thus bypassing the majority of the rural population in most LDCs (Schumacher, 1973). The simultaneous development of these rather perverse tendencies has culminated in a number of cumulative socially undesirable side effects broadly manifested in mass migration into cities, high rates of urban unemployment and increasing mass poverty. Unfortunately too, there obnoxious developments are taking place in countries where the welfare institutions of the state are virtually inoperative or nonexistent.

It is from this concern with creating employment opportunities of workplaces that a number of institutions and individuals have joined forces to search for and support

technologies that could facilitate the attainment of employment-intensive, redistributive and basic needs objectives. These efforts while demonstrating quite clearly that opportunities for labour-intensive efficient technology exist in the LDCs,[1] have nevertheless revealed that these technological opportunities have not been fully or optimumly exploited. Stewart (1987) suggests that the failure to adopt appropriate technology could largely be explained by the narrow conceptualization of the technological choice question which, in turn, has led to a partial diagnosis of the real problem and the subsequent partial policy prescriptions and intervention mechanisms directed largely at the micro aspects.

The crux of the matter as explained by Stewart and indeed shared by many others[2] is that technology choice is a far more complex matter than generally assumed. It is not only an issue involving decision making units, with specific objectives selecting a particular technique from a shelf of technology subject to the state of technological knowledge and other economic resources constraints, but also a decision about consumer preferences, the type and quality of the product to be produced, potential markets, government and the whole socio-economic framework. In addition, a technology choice decision reflects certain behaviourial aspects of technology suppliers, foreign aid donors and the time preferences of the society in question. Consequently the analysis of technology choice and the implied solutions can not be really meaningful without commensurate consideration of the whole set of these complex forces.

Building on an analytical scheme mainly developed by Stewart (1977) and taking the grain-milling industry in Tanzania as our case study, an attempt is made in this paper to highlight on some of the salient and intricate forces that directly or indirectly influence technological choice decisions at the micro-level. It will be shown that these factors operate through both micro and macro influences. Within this thrust we seek to demonstrate that a cautious approach is needed when comparing technology choice decisions among different production units. Small and large scale firms may, for example, exhibit significant differences in terms of product characteristics, market orientation, work organization, efficiency in factor use and spatial concentration - factors which may impel the two sets of firms confront different production functions and experience different technological constraints.

The rest of the paper is organized as follows: section two sketches the sources. Concepts and methodology are outlined in section three. Section four examines briefly the institutional background to the current milling practices in Tanzania. Section five describes and analyses the technological options available in the household, custom and merchant milling sub-sectors. The relationship between techniques, products and markets is examined in section six. Section seven evaluates techniques in relation to appropriate technology characteristics while section eight examines the selection mechanisms. And finally, the conclusion is presented.

2. Data Sources

The technical data underlying this analysis were gathered from a carefully selected sample of 49 maize and 16 rice milling units scattered all over the country in Tanzania. Two sets of cross sectional data were collected: one for 1982 and the other for 1983. Additional information was obtained from relevant ministries and institutions. Initially, data generated during the pilot survey (which covered 170 million units) had enabled us to classify milling units into three broad categories on a functional basis: household, custom and merchant mills (see section 4). The sampling frame adopted was therefore purposefully designed to reflect these categories and also to capture the spatial (rural and urban) character, as well as the activity composition (maize and rice) of the milling units. Data were collected on a number of variables but the major quantitative ones were output, labour, capital and material inputs (i.e., raw grains, packing material and fuel). Output was measured conventionally in both monetary (value added) and physical (tons) values. Labour was measured in terms of number of workers, wage-bill, and man-hours. Capital was initially measured as a stock (i.e., purchase price plus cost of installation) and later converted into an annual capital charge[3]. Material inputs were measured in monetary values and reflected their purchase or expenditure values. Our study is thus very much conditioned by the type of data generated during the survey[4].

3. Concept and Method of Analysis

Given the thrust of many studies on the nature of LDCs technology (outlined in section 1), the concept of appropriate technology (AT) has become central to the analysis of technology choice. Being a relative concept, appropriate technology has meant different things to different people. Stewart has however, conveniently grouped the many and diverse definitions of AT into two main contrasting views. The first view derives from welfare economics and regards AT as a set of techniques which can optimize social welfare when factor prices are shadow priced. The second approach involves the specification of certain set of technological characteristics which are considered ideal in a given socio-economic environment (Stewart 1987:2-3). But as Stewart rightly points out, although none of the two views is perfect, the specific-characteristics approach offers a better perspective than one based on social welfare because by recognizing that all techniques are in a sense inappropriate the former approach sets the basis for new spurt of action in further research and search for AT.

It is in the above mentioned context that this study has largely adopted the specific-characteristics approach to define AT in the grain-milling industry. According to Tanzania's long term basic industrial strategy-BIS (1975-1995), the "Basic industries - those which use domestic resources to produce essential commodities for consumers or domestic industries - will receive priority" (URT, 1976:17). Working from the BIS objectives which <u>inter alia</u> stress the need to achieve structural

change and self-reliance, we have found it useful to define AT in terms of the extent and effectiveness to which techniques (i) use locally available resources particularly labour, (ii) economize on scarce resources especially capital and foreign exchange, (iii) ensure full capacity utilization, (iv) generate linkages, (v) minimize costs and (vi) produce appropriate products.

The logic underlying the choice of this set of AT characteristics crucially hinges on the (perhaps controversial) assumption that Tanzania's broad development policies reflect the economy's societal, cultural, socio-economic, political and technological needs and hence constitute sensible norms against which performance can be judged. This approach has also an appeal for pragmatism in the sense that the implied AT solution is more likely to be acceptable to Tanzanian policy makers. Ambiguity may still arise however, if conflict occurs among the unweighted AT characteristics. Furthermore, the solution (AT) arrived at under this approach could still be technically inefficient. We have tried to handle the latter problem by resorting to partial factor productivity indices and by estimating benefit-cost ratios for alternative techniques at both market and 'corrected' prices. Additionally, in justifying the existence of alternative techniques, we have found it instructive to supplement the anecdotal method (of identifying, and listing alternative techniques with their technical characteristics) with production function analysis (which assesses empirically the extent of factor substitution and the significance of scale economies)[5].

4. Institutional Set-up and Milling Practices

Colonial government intervention into the food grain sector in Tanzania was limited to the pricing, distribution and the marketing functions. At that time, government intervention was largely prompted by the desire to rationalize food trade so as to achieve food self-sufficiency nationally and to build surpluses for meeting post (Second World) war shortages in other countries of the 'Sterling' block. Thus up to independence (1961) and indeed before 1967, the milling function remained in the hands of private millers. The (1967) Arusha Declaration however, called inter alia, for public intervention into the strategic sectors of the economy so as to facilitate the achievement of Tanzania's major objectives of socialism and self-reliance. Subsequently, in the food grain sector, the 8 major milling companies were nationalized and amalgamated to form the National Milling Corporation (NMC). From 1967 to 1976, NMC's functions were limited to the manufacturing, processing and importation of food products. With the dissolution of the cooperative unions in 1976 however, NMC assumed additional functions with exclusive rights for purchasing farm level supplies and distribution of final products to retailers. Although officially NMC maintained a statutory power over the marketing of grains between 1976 and 1983[6], official records indicate that a large circuit of grain flow bypassed this official net. For the 1983/84 marketing season for example, about 70% of marketed maize output and 80% of rice were handled by the parallel market (MDB, 1983). This clearly suggests that there is a sizable informal milling

capacity coexisting with the public milling capacity.

In terms of enterprise organization the above institutional changes have created a three-tier structure of milling practices in Tanzania. Large scale (merchant) milling, whereby grains are purchased by the miller from villages and/or other public marketing institutions, then milled, packaged and distributed nation-wide but particularly in urban areas, has remained the preserve of the publicly owned NMC. Custom milling, whereby grains are supplied by subsistence consumers in turn for a milling fee, remains largely in the hands of small scale private operators. At the household level, particularly in the rural homestead, traditional methods of hand grinding and manual milling are still being practiced. As we will show in the following sections this institutional structure has not only influenced the ownership aspect of technology but also is intimately intertwined with other technological aspects such as the scale of operation, the type of product and markets for products.

5. Technological Options

The question of whether or not meaningful technological choices exist in the LDCs is very crucial for policy. If on the one hand technological rigidity prevails then the question of technology choice becomes less significant and for a given branch of industry the major concern becomes one of industrial composition (Stewart and James, 1982:2). On the other hand the existence of a range of technological choices necessitates the

need for creative search for AT through a careful selection and or alteration of factor proportion embodied in either new equipment and or as Winston (1979) suggests, in used equipment.

This study has found that a number of milling techniques exist in the production of rice and maize meals in Tanzania. These range from simple household milling methods involving a pestle and mortar or a hand-mill, through the small scale mechanical hammer mill used by custom millers to the technically sophisticated roller-mill used in the merchant milling sub-sector. For the industry as a whole and if differences in products were to be held constant, variations in input requirements were quite substantial (Table 1). For example, initial investment requirements in the most capital intensive roller mill were 154 times greater than those in the most labour intensive hammer mill and 1154 times greater than those for the manual mill. Average employment varied widely too. Operation of a hand mill normally involved one person. An average hammer mill employed six persons while a typical roller mill employed about 37 persons. The range of labour intensity (defined as the investment required to create one new productive manhour) was also found to vary substantially across techniques. For instance, Shs. 1,000 invested in a 120 tons per day (t.p.d.) maize roller would generate 54 manhours of employment whereas this same amount would generate 625 manhours of direct employment if invested in the smallest hammer mill. There were mills with hourly rated output capacities ranging between 3-10 kg. for manual mills, 250-1,000 kg. for hammer mills and 1,000-5,000 kg.

for roller mills.

Even within each of the production unit categories examined (i.e., household, custom and merchant mills) variations in technological characteristics seem to have given rise to different technological choice decision making rules. In the household economy, important tradeoffs revolved around, hand pounding, the use of hand or pedal mills, using services provided by the custom mill and purchasing meals from the shelf of a retailer. From the interview responses it became clear that for the majority of the households, hand pounding (or hand hulling) was inconvenient because it was arduous and time-consuming. If two people were to be involved, it would take about 6 hours of hand pounding to obtain 10 kg. of maize meal. Moreover, in case of maize milling losses were found to be extremely high and averaged between 30-40% particularly where milling involved complete removal of peels (bran) and embryos (germ).

In the circumstances, the acquisition of a hand (manual) mill would certainly reduce the hand pounding time by almost half. The capital cost involved (about Tz. Shs. 5,000-8,000/=) would be enormous, however, and would fall quite outside the normal expenditure pattern of an average Tanzanian household (with an annual per capital income of Shs. 2,000). On the other hand for the household consumer, using the services of a custom mill did not entail a capital cost. One simply paid a fee for the grain to be milled. Thus the choice to purchase either a house-hold manual mill or to use custom milling services involved a trade-off between capital and recurrent costs - a situation

quite similar, as Uhlig and Bhat (1979) noted, with a choice in an industrial society between the purchase of a washing machine and the use of a laundrette. Sometimes, apart from money costs, other forces could as well be at work. For example, in Arusha region (in the northern part of Tanzania) the use of the pedal mill (a manual mill attached to a bicycle was unpopular because women (who normally grind grain) have a traditional dislike for riding a bicycle. Men on the other hand, felt it was somewhat embarrassing to get involved in a hitherto traditionally considered women activity. The importance of social values in technological choice decisions was also expressed in another subtle form. For the rural womenfolk, as one woman observed, while walking to the custom mill and while waiting for the grain to be milled "We (women) get an opportunity to exchange views. Besides, for us it is like having a break". Thus an added flexibility of the mechanical custom mill is that unlike the merchant mill it can still provide an opportunity for such social interchange.

In the custom milling sub-sector one could also observe substantial differences (in terms of output capacities, sources of equipment and motive power) between techniques employed by various mills. In maize milling, the single stage hammer mill technology was dominantly employed. Typically hammer mills grind all maize in a single stage into a light brownish whole meal 'dona' flour thus retaining almost the entire part of the grain including the bran and the germ. The extraction rate was very high and averaged 98%. Maize hammer mills varied in size with

hourly output capacities ranging from 250 to 1,000 kg. Their power requirements also ranged from 15 to 54 hp/hour per tonne of meal. About 58% of the maize hammer mills were locally manufactured with the rest imported from UK, West Germany, Denmark and the USA. Hammer mills were found in both rural and urban locations and were powered by either electric motors or diesel engines. Custom rice mills employed either the Engelberg huller or the small rubber roller sheller[7]. All the rice mills had been imported (from Japan, UK and West Germany). Most rice custom mills were small with rated hourly capacities ranging between 250 and 1,000 kg. Rice hullers like hammer mills were also found in both rural and urban locations and were powered by either electric or diesel engines.

The heterogeneous technological structure of the custom milling sub-sector (as reflected in different mill sizes and models from a wide range of equipment suppliers) has given rise to marked variations in prices of milling equipment (probably reflecting their differences in terms of quality, durability and sophistication). For example, initial investment costs for the largest hammer mill were 2 1/2 times those of the smallest hammer mill. Diesel powered custom mills were also on average expensive to purchase and operate than electric powered mills (see section 7). The latter were however, considered to be more prone to mechanical breakdown than the former. Sourcing of equipment and plant location provided another important explanation for variations in investment costs. At market prices an imported

hammer will cost 8% less than the only locally made; but at shadow prices the optimality of the latter was indisputable. Building costs in rural areas were about 15% lower than those in urban areas because of more extensive use of family labour and lower land costs. For the potential investor therefore, such price-quality differences provide considerable flexibility in the choice of technology permitting one to select the most competitive option.

The merchant milling sub-sector was dominated by large scale imported roller mills. Typically a roller mill consists of a series of machines which clean, condition degerm, grind, sift and classify output. In maize milling, roller mills were used to produce two types of sifted maize flour: 'sembe superior' (fully degermed and produced at an extraction rate of about 80%) and 'sembe standard' (partially degermed and produced at an extraction rate of 90%). In rice milling large rubber rollers were being employed. Rice was mainly milled raw at an average extraction rate of 65%. There was little control of moisture and high percentages of broken grain (ranging between 10 and 30%) were reported. In terms of size, roller mills fell into three distinct size groups: those with rated capacity output of 24 tons per day, 50 t.p.d. and 120 t.p.d. Location-wise all merchant mills were located in large towns with Dar es Salaam (the former capital city) accounting for 51% of the total installed capacity (estimated to be 411,000 metric tons annually - inclusive of wheat).

Apart from differences in rated output capacities between

roller mills (which largely explain the observed differences in prices of milling equipment, employment demands and hence factor intensities[8]) a glance at the technological structure of the merchant milling sub-sector would easily suggest its limited flexibility in terms of choice of milling equipment. The first glance simplicity is, however, deceptive for it masks certain important technological details in the multi-stage roller mill production process. A closer examination of the process involved in producing sifted maize meals revealed three distinct but closely interrelated sub-processes. The core activity of milling which involves degermination (i.e., separation of germ and bran from grain kernel) and two other peripheral activities of materials handling and packaging.

In the materials handling sub-process at least three technology variants could be employed to transfer grain from lorries or wagons to the warehouse or silo and finally into the mill: the manual feeding process, the semi-automatic feeding process and the automatic feeding process. Table 2 shows that although operations in the three techniques involve unskilled tasks, there are marked differences in absolute labour demands suggesting that the substitution of manual for machine operations is indeed feasible. Substantial flexibility between the use of labour and machines was also demonstrated by the availability of at least three alternative packing systems at the packing stage. As shown in Table 3, the manual packing system for example, required primarily services of the unskilled operatives and

placed negligible demands on capital. The automatic packing line on the other hand, was characterized by capital costs of about 200 times higher than the manual packing line.

Unlike the peripheral processes, the core milling sub-process appear to be technologically determined in the sense that its design principle does not permit easy factor substitution. Although the process of degermination and milling could be achieved by employing different types and makes of degermers, employment requirements are of the overhead character quite invariant with respect to scale and machine intensity. However, some form of choice exist in the source of supply of the core milling equipment and as Uglig and Bhat (1979) have shown there are significant price-quality differences among degermers supplied by various manufacturers.

The preceding anecdotal evidence would seem to suggest that opportunities for choosing among alternative techniques exist in the grain-milling industry in Tanzania. This finding was also empirically confirmed by the production function estimates. Using both the Chenery et.al 1961 and Kmenta's CES linear approximation equations[9], the computed factor elasticity of substitution coefficients (ranging between 0.75 and 0.86) were found to be positive and statistically significant from zero suggesting flexibility in the substitution of labour for capital. Furthermore these quantitative results implicitly suggest hat factor prices would tend to exert some influence on technological choices. To that effect, macro-policies on interests rates wages and tariffs stand to have momentous influence on the environment

in which decisions on technological choice take place.

6. Products and Markets

Ideally, comparison of substitution possibilities between different techniques should be made when the final product is a close - in theory a perfect - substitute. Clearly, from the point of view of consumers custom and merchant mills produce products which are different in terms of quality, provision of consumer satisfaction and service characteristics. In addition, they serve different markets. These contrasts are particularly marked in maize milling and raise the question of whether or not it is meaningful to compare custom vis-a-vis merchant milling techniques. As indicated earlier the three types of maize meals (wholemeal, sembe standard and sembe superior) were being produced at extraction rates of 98%, 90% and 80% respectively. The sifting process, by removing a significant portion of the germ and bran from the endosperm, makes the flour less nutritious than the wholemeal (Table 4). However, whereas the wholemeal flour may turn rancid after three weeks, the sifting process greatly extends the shelf life of sembe standard to about 6 months and that of superior sembe to about 12 months. The limited shelf-life of the wholemeal mimits its marketability and ties custom mills to local markets. In terms of texture, the sifted flour has a finer and more even granularity, is whiter in colour and boils faster than the wholemeal. These characteristics have had a strong appeal for customer tastes and most of the urban consumers interviewed indicated their strong

preferences towards sifted meals whenever they were readily available and if they could afford them.

Apart from producing products with contrasting qualities, custom and merchant mills offer services and serve markets that markedly differ. As pointed out above, the limited shelf-life of a wholemeal confines the services of a custom mill to localized markets. The extended shelf life of the sifted meal greatly facilitates its nation-wide distribution. For the merchant mills, the larger and more distant markets they serve necessitate the need to conveniently package their products. Custom mills however, do not carry out the packing and storage functions partly because their markets are localized but also partly because NMC has the legal monopoly power over the distribution of major food grains. To that effect, the market is to some extent, institutionally determined. But there are other influences on the demand for a particular product. For example, for a full time urban worker walking to and waiting at the custom mill could be inconvenient because time has a premium in this case. Moreover, since urban households normally do not have grain supplies of their own the cost of time and procurement increases as supplies have to be obtained from the middleman, peasants or distant relatives. In such circumstances the urban worker may prefer purchasing packed meals directly from the shelf of the retailer to services offered by a custom mill. On the other hand, the rural peasant may attach less weight to time spent at the custom mill. Besides, retail stores stocking merchant mill products may be distantly located. The rural household has,

moreover, its own supply of grains and can improve the taste of the wholemeal through a careful selection and prior treatment of grains. The limited life of wholemeal flour is not such a problem because the household would normally take a small quantity of maize to be milled at a time. But also, the rural household may be constrained by ready cash to purchase the packed meal. Thus the rural and urban consumption regimes invariably influence the market for grain mill products in different ways.

The demand for particular grain mill products has also been influenced by government intervention. Up to 1983, government maintained a 55% explicit subsidy for maize meals produced by NMC. This subsidy did not cover maize meals produced by custom mills in both rural and urban areas. Although the subsidy was mainly intended to protect the real purchasing power of urban waged earners, it was in effect a deterrent to the expansion of custom milling sub-sector whose products became relatively expensive. In 1979 government intervened more actively in the food grain market by imposing a ban on the production of sembe superior. This was done mainly to cope up with the acute grain shortfalls at the time by encouraging consumption of sembe standard and the wholemeal flour which make better use of grains (i.e. have higher extraction rates). There were no riots nor any other forms of consumer resistance following the ban. Most consumers interviewed indicated that they had become used to sembe standard.

The implications of all this for technological choice are as follows. First, since private millers were not allowed to

distribute milled products, they could only operate on a custom milling basis. Second, the limited size of the market for custom mill products, the small quantities of grain which are supplied in bits and short production runs coupled with the relatively short shelf life of the wholemeal (in the case of maize) have necessitated the use of mills with small capacities. It is clear then that markets influence both the scale and the type of product. This most probably explains why 78% of the custom mills surveyed had an hourly rated capacity of less than one ton. The limited market also explains why 52% of the millers operated several units simultaneously. Thirdly and particularly in maize milling, the specification of the product is of great importance in determining the range of milling techniques. The choice to produce a sifted maize meal implies the choice of a roller mill technology. This is because apart from the above-mentioned institutional factors, technically, production of sifted meals entail a certain level of machine sophistication involving special particle size control devices such as the degermer or cylindrical rolls which are lacking in the custom hammer mill. It could be possible of course for a hammer mill to produce standard sembe if a sifting device is installed following the milling sub-process; but certainly not sembe superior. And although is technically possible to operate a maize roller as a custom mill, it is not economically feasible to do so. It appears then that the choice of product and the choice of mill specification are inextricably intertwined. And, the more rigorously we specify the product the narrower the range of

alternative techniques becomes. This however, it should be emphasized, does not necessarily suggest presence of technological determinism. For as already pointed out, apart from differences in scales and sourcing of milling equipment, the multistage character of the roller mill technology permits different techniques to be employed in the peripheral operations. It does suggest however, that appropriate factor proportions could be achieved by changing the product composition of output. Finally, an important analytical insight generated by this finding is that care should be taken in comparison of efficiency and the extent of substitution possibilities between custom and merchant milling techniques. The two units product products that are not perfect substitutes, they serve different markets and employ different milling techniques[10].

7. Appropriate Technology Characteristics

This section assesses the performance of alternative milling techniques in relation to the AT characteristics specified in section 3.

(i) Potential for Employment Generation

For each technique the potential for employment generation is assessed by using the capital - labour (K/L) ratio defined as the investment required to create one productive manhour[11] Table 1 presents some evidence on labour intensity in se'ected milling techniques. Generally, within each technology category labour intensity diminishes with scale. For example, in the largest

custom hammer mill, investment requirements per manhour are roughly treble those of the smallest hammer mill while those in the 120t.p.d. maize roller are 1.6 times those of the 24t.p.d. maize roller. Clearly, the picture that merges from Table 1, is that within each sub-sector, milling techniques at the smallest end of the spectrum possess higher employment potential per unit of investment than those on the largest end of the spectrum. An additional particular aspect of the custom milling sub-sector is the negligible demand it places on specialized skills (Table 1). It must be stressed though that this has not constrained skill formation. Indeed the sub-sector has played a crucial role in the development of artisanal skills through the system of apprenticeship and 35% of the workers interviewed indicated that they had received training as apprentices. Evidently, the relatively unsophisticated custom hammer mill technology has not only made it possible for local users to operate it but also for local manufacturers to adapt it to the available levels of skills. On the other hand, the production of high quality sifted maize and rice meals impel the use of more sophisticated machine designs and operating characteristics, such as the roller mill. For such a machine, the need for more specialized skills to carry out general management and administration functions, supervise plant operation and maintenance becomes apparent. Compared to custom mills, roller mills are therefore, not only capital intensive but also skill intensive. And since in Tanzania, roller mills are being imported in entirety, their use exacerbate

the problem of foreign exchange shortage.

(ii) Effectiveness in the Use of Capital

A crucial question however is whether or not the observed greater labour intensity of smaller firms reflect efficiency in operation. If the most labour intensive mills also exhibit lower output-capital (Q/K) ratios, then they are inefficient. But as Table 5 shows, within each technology category, the smallest mills involve less capital expenditure per unit of output than the larger mills. They are so to speak fairly effective in the use of capital. In this case, the paradoxical situation whereby the inappropriate (more capital intensive) technique tend to be associated with high out-capital ratio does not arise. Consequently the static trade-off between employment expansion and output growth becomes less significant. Furthermore the evidence available, seem to corroborate Kaldor's (1978) postulation that in the LDCs, the major reason for capital intensive firms to have low capital productivity is the absence of significant economies of scale. Indeed, our estimates derived from a standard Cobb-Douglas production function analysis revealed that the grain-milling industry in Tanzania is characterized by constant returns to scale[13]. The underlying causes for mills' failure to realize economies of scale were mainly found to be: under utilization of capacity; greater difficulties involved in the operation of sophisticated machines; lack of skills and high incidence of machine breakdown.

(iii) Capacity Utilization

The importance of capacity utilization lies not only in its relation to the choice of technique (since ratios between inputs and between inputs and output tend to vary with capacity utilized) but also in broader issues of resource allocation and utilization (as a crude indicator of efficiency). Full capacity utilization as defined here relates to the miller's desired or planned level of output. Evidence gathered during the survey revealed that most mills did not operate at full capacity. Capacity underutilization rates were highest in the custom mills where it averaged 70%. The most affected mills were the small rice hullers which operated at 24% capacity. Rates of capacity utilization were generally lower in rural custom mills (by about 10%) than their counterparts in urban areas. With regard to the major causes for excess capacity among custom mills the following factors were frequently mentioned: (a) insufficient supply of grains, (b) constant power failures and diesel shortages, (c) lack of spares and (d) the nature of the production process which because of customer participation can operate only day-light and which involve large amount of small quantities of grain. Merchant mills were found to be operating at slightly higher rates of capacity utilization (65% for maize and 45% for rice mills) than custom mills. Shortages of grains were not a major constraint there as NMC's large mills had monopoly over marketed domestic and imported grain. Excess capacity in merchant mills was mainly attributed to constant machine breakdowns, shortages of spare parts, power failure and in case

of rice mills over capacity which resulted from poor project planning at the investment stage. Overall, it appears that irrespective of the type of technology in use, capacity utilization rates could be improved with increased supply of grains, fuel and better planing of maintenance and repairs.

(iv) Generation of Languages

According to Tanzania's Third Five Year Plan (1976-81), "The major objective of the twenty year (industrial) plan is to restructure the industrial sector by increasing domestic linkages" (URT, 1976: Vol 1 p. 43.). Linkages constitute therefore, an important consideration in the selection of basic industrial activities. In the absence of reliable information on consumer expenditure patterns, saving propensities and disaggregated input-output data, the exact magnitude of the linkage effects can not be ascertained. Accordingly, we have relied on the volume and direction of direct transactions between the grain-milling industry and other sectors of the economy to infer the relative importance of sectoral linkages. Consumption linkages are probably the trickiest to assess. We can only speculate that since experience elsewhere in Africa suggests that low income families tend to spend extra income on labour intensive commodities and that rural consumers spend a large proportion of income on food produced in the rural areas[14], the custom milling activities will most likely generate more consumption linkages than merchant mills. But in the long run, given Engel's law, the consumption linkages of the grain-milling

industry are bound to be weak. However the sector's backward linkages to the agricultural economy are very strong since 98% and 90% of the raw materials used in custom and merchant mills respectively comprised of raw grains. Backward linkages to the industrial sector were in form of supply of capital goods to the custom mills and supply of packing materials in case of merchant mills. For custom mills, forward linkages were practically non existent. The by-products of merchant mills however, are important ingredients in the making of poultry and animal feeds. The germ by-product was considered instrumental in the setting up of an oil extraction plant in the future.

(v) **Profitability**

In order to evaluate the relative profitability of alternative techniques, the return to capital (or surplus) was compared to the cost of capital. The return to capital is the difference between value added (V) and the wage bill (wL). The cost of capital depends on the underlying investment cost, the durability of capital equipment and the interest rate and is defined as the investment cost (K) times the capital recovery factor (c)[15]. The ratio of the return to capital to the cost of capital is the benefit - cost ratio (V-wL)/cK.

Table 6 summarizes the estimated private and social-benefit-cost ratios for each of the selected milling technique. Two discount rates (10 and 15%) and three capacity output levels have been assumed. Within the custom milling sub-sector it is the least labour intensive 22.5 t.p.d. hammer mill which generated

the highest surplus per unit of investment. There could be in this case a potential conflict between the objectives of employment maximization and output growth. In urban areas, where there is a choice between electric and diesel power to drive a custom mill the preference will be for electric power as it is relatively more profitable by 27%. At the existing market prices, imported mills have an edge over local mills in terms of profitability. At corrected prices however, the optimality of the local manufactured mill becomes obvious. In merchant milling, the most labour intensive 24 t.p.d. roller had also benefit-cost ratios which were 23% (in case of maize) and 58% (for rice) higher than the least labour intensive 120 t.p.d. roller if market prices are assumed. In terms of social benefit-costs the differences widen to 26 and 68% in favour of the 24 t.p.d. roller which also (as already pointed out) uses capital more effectively. The inferiority of the 120 t.p.d. roller is thus further reinforced.

Changes in the discount rate leaves the ranking of alternative milling techniques unchanged. Excess capacity on the other hand, reduces the overall profitability of milling techniques, but the rate of profitability decline is much faster in the most capital and skill intensive merchant mills. Changes in imported machinery prices e.g., a fall in prices following devaluation of local currency reduces profitability of merchant mills but their ranking is unaltered. They do however affect the choice of technique in the custom milling sub-sector tilting the balance in favour of locally produced hammer mills.

(vi) Appropriate Products

The BLS makes an implicit statement about the need for producing appropriate products by emphasizing that the goods produced should be able to meet the basic consumption and health needs of the (generally poor) Tanzanian masses. An appropriate food product in this case would be the one that is less deficient in nutrients and one which the majority of Tanzanians can afford. In this context the fully degermed sembe superior could be classified as inappropriate on three grounds. First, of the three maize meals it had the least nutrients. Second, it was being produced by a less appropriate technology and lastly the majority of Tanzanian (low income) consumers could not afford it. Before it was banned sembe superior used to sell at twice the price of sembe standard and 2.3 times the price of the wholemeal. Sembe superior was thus a luxury commodity consumed mainly by the few high income groups in urban areas. Ideally one would not regard sembe standard as a luxury. Firstly, although in this case it was being produced by a less appropriate technique it could, in principle, be produced by a hammer mill if accompanied by a sifting device. Secondly, random consumer interviews revealed that over 80% of the consumers who bought the wholemeal from retail stores normally sifted it (almost to an equivalent sembe standard) before cooking. And lastly although the price of sembe standard was about 28% higher than the price of maize wholemeal produced by NMC (before the subsidy) it was almost at par with the (imputed) price of a wholemeal produced by custom mills.

In rice milling, rice hulled by the large roller mills had almost same nutrients as those produced by small rice hullers. However, it sold at a premium (of about 15%) because it was considered as being of high quality in terms of uniformity in size of grain, absence of foreign particles and contained 10% fewer broken grains than custom-milled rise. But if it is also recognized that the large rubber roller is less appropriate in terms of economy in overall resource-use, then merchant milled rice could be regarded as a less appropriate product. What one tends to observe is that modern large scale and capital intensive merchant roller mill are associated with the production of less appropriate products while small scale old-vintage custom milling techniques tend to produce more appropriate products. This observation implicitly suggests that if appropriate techniques are to be adopted and popularized then it may be necessary particularly in the LDGs to select and consume appropriate products. This is imperative "...because the production of inappropriate products generally requires inappropriate technology, and because meeting of the basic needs of poor people requires the production of appropriate goods to meet their consumption needs and to provide appropriate productive equipment" (Stewart 1987: 292).

8. Selection Mechanisms

In view of the fact that both the custom mill technology and the small 24t.p.d. roller have the greatest potential to generate employment opportunities and profits in both private and social

terms, the decision taken by the NMC (in 1970, 1979 and 1983) to expand its milling capacity on a large 120t.p.d. roller basis needs to be explained.

(i) **Resources and Prices Matter**

About two-thirds of commercial milling activities in Tanzania is carried out by small scale custom mills. Their exact number is now known. But a rule of thumb about the number of rural mills would read as: one mill for every four villages (World Bank, 1981:5). With about 8,000 registered and 7,200 unregistered villages in Tanzania one would expect about 3,800 custom mills in rural areas alone. The multiplicity and spatial dispersion of custom mills is largely explained by the substantial ease of entry characterized by relatively low initial investment costs. The costs of land and buildings are low because millers use their own residential plots to build mill sheds. The use of family labour or relatives reduces significantly the wage bill. In contrast, the market orientation of the merchant mills compel them to be sited in strategic urban places where the cost of land and rent are high. The sophisticated multi-stage character of the roller mill does not only require specialized skills involving large wage bills but also special building designs such as stories which allow the use of gravity lines for transferring the product from one stage to another. Furthermore, bulk storage for both raw materials and inventories require more storage space involving extra building costs. If it is recalled that there is flexibility of choice

among alternative milling techniques, prices of inputs would seem to very much matter in that they determine actual choices at the enterprise level and the distribution of investment between custom and merchant milling sub-sectors. But certainly the role of prices is much more complex than that assumed by the neoclassics. Because of non-homogeneity of factors, firms face different factor prices. Large mills for example pay higher wage rates than small mills.

To that effect, macro-policies which influence product and factor prices, play an important role in the determination of choice of technique. We have seen that by subsidizing the price of sembe standard government was, in a way, encouraging the expansion of inappropriate milling practices. Equally, government's credit and import rationing policies have tended to encourage large scale mills with substantial credit collateral, lower risk of default, political and economic influence. For example, of the 30 out of 54 custom millers who indicated to have applied for loans from public credit institutions only 10 were successful. In addition, negative real rates of interest for both domestic and foreign loans coupled with the overvalued exchange rate greatly subsidize imported mills thus encouraging capital and foreign exchange intensity in production (Bagachwa, 1987).

(ii) Product Quality

Factor prices could be an important determinant of technology choice but definitely they are not decisive. Other

factors enter. Even as early as 1971 NMC envisaged in its long range planning that it would be "necessary to increase roller mill capacity and gradually phase out existing hammer mills" (NMC, 1971:3). This was to be done in view of the expanding urban demand for sembe superior and also as explained later "the hammer mill's extraction rate can not be controlled and the quality is not therefore high" (World Bank, 1981:14). Consequently the subsequent expansions of the roller mills produce final products "with more consistent and uniform in grade and quality."[16] The cry out for high quality products generally leads to the use of inappropriate techniques to produce inappropriate products. This seems to be inevitable because high quality products reflect demands by high income societies and are normally produced by new vintage and capital intensive machines. The sifted meal for example, is very much a brain child of technological development of the 19th century. The modern multi-stage roller mill "was thus a case of technical progress that was essentially directed at product innovation rather than at cost reduction for a given product" (Uhlig and Bhat, 1979: xvii). Sifted meals were introduced in Tanzania in early 1950s after becoming 'successfully' popularized among the Kenyan elite. Before private mills were nationalized (1967) the fully sifted sembe superior was mainly promoted through advertisement and fine packaging. Thereafter, with NMC assuming monopoly powers over production and distribution of milled products, advertisement became less important as the market was more or less guaranteed. Nevertheless, the seeds for imitative

patterns of consumption that favour high quality products had already been sown. Indeed, as other case studies have shown, it is now established that product quality has become an important determinant of technology choice in Tanzanian industry[17].

(iii) Empire Building Managers

Our discussions with the NMC officials clearly revealed that when making technological choice decisions, parastatal managers were free to pursue their objectives which turn out to be inconsistent with those of the government. This loophole was dilated by the failure on the part of the parent ministry to provide and enforce a well defined set of goals to the NMC. The pursuit of self-imposed motives by the NMC managers has been an important cause of choice inappropriate milling techniques. The manager's choice and preference for large scale rollers was guided by two main considerations. One, is that of product quality which we commented on earlier. The second was the alleged high rated engineering efficiency in terms of physical output per unit of time. But the experience with NMCs large scale roller mills has proven that the rated engineering efficiency is not uniquely determined. Its realization depends on certain technical and infrastructural prerequisites which are largely missing in Tanzania. It is apparent then, that the two objectives were pursued dogmatically irrespective of the enormous economic costs involved - a tendency labelled as the 'engineering man' by Wells (1973).

The subjectivity element in technological choice of this

type is not hard to conceive. Apart from the desire to satisfy the consumer preferences of the elite, there is also the human desire to be identified with power; the personal esteem derived from being a manager of a large modern and mechanized milling unit. Large sophisticated technology usually located in a modern sector enclave appear to be an important source of such identity (Winston 1979: 840). It is this quest for 'empire building' which explains the paradox that despite the reality of foreign exchange, spares and skill shortages at the NMC there is still hope and pride to expand the larger, more skill intensive and mechanized roller mill.

(iv) Foreign Finance

The impact of foreign finance on technology choice in the Tanzanian context has been examined in more detail elsewhere and need not be greatly emphasized here[18]. In most of the cases examined, foreign aid has been found to have the preference for new, large scale and in most cases turnkey projects rather than the funding of recurrent cost and rehabilitation. It has also been found to constrain the sourcing of equipment to the donor country or supplier. The selected techniques therefore, tend to reflect the socio-economic conditions in the (normally high income developed) donor countries and are for sure, inappropriate for the low income LDCs. In the grain-milling industry in Tanzania, there appeared to be a close connection between the choice of financing and the sourcing of equipment. Three of the British manufactured rollers had been financed by supplier's

credit from Britain while another three German made rollers were financed by supplier's credit from West Germany. One can not simply dismiss this as a coincidence particularly in a situation where managers are desperate about securing funds for financing their projects. In the circumstances, foreign finance could be a potent source of technological dependence.

(v) Technological Capabilities

The implicit assumption underlying the conventional view of technology choice is that there exists a well defined set of technological options on the shelf and that firms are well informed about the available alternatives and have the capacity to scan, assess and select the most competitive option given a set of objectives. The findings of this study belie this notion of perfect information. In the custom milling sub-sector for example, it was found that about 80% of the mill proprietors did not have sufficient prior knowledge about costs of alternative milling equipment and their operating characteristics, product demand and input supply patterns and potential plant sites. No wonder therefore, that in a few cases, building and equipment appear to have been excessive or misdirected.

The supply of indigenous managerial skills was also limited in the merchant milling sub-sector. Even at the time of the research, the 15 years old NMC had a number of key posts- including those of chief accountant, cost accountant, maintenance engineer, engineering and processing manager and a silo and grain handling specialist - still vacant. The most technically

qualified miller held a diploma in flour-milling while 5 our of the 25 branch managers had prior managerial experience in grain-milling. To a large extent, the indigenous managerial constraint explains why in all cases involving decisions to rehabilitate and/or establish new milling capacity there was no active local expertise participation in the key technological tasks: from feasibility studies through civil engineering works to the identification and bargaining process with machinery and input suppliers. The limited discussion that took place was a mere formality to ensure official endorsement of the project.

As explained in point (iv) above, the preponderance of foreign experts in the making of technological decisions is bound to encourage the selection of inappropriate techniques and products. But more important, particularly in the long run, it facilitates leakages of potential investible surplus and foreign exchange. The latter point is indicated particularly (implicitly) in the World Bank (1980) report on the appraisal and rehabilitation of NMC grain storage and milling capacity. The report identified 16 top technical positions where additional staffing would be required. The top 6 positions were classified as highly specialized and required expatriates of considerable experience, at a cost of US dollars 3 million for a five year period. The remaining 10 positions were to be filled by Tanzanians at a cost of US Dollars 0.4 million over the same five-year period. Employment to these positions were however, to be "on conditions satisfactory to IDA" (World Bank 1981:2). Certainly, the absence of indigenous technological capabilities

in the grain-milling industry has been not only an important explanation for the selection of inappropriate milling techniques, but also has fostered the reproduction of technological dependence.

9. Conclusion

The preceding analysis has clearly demonstrated the economic viability of the custom milling-sub-sector in terms of employment generation, effective utilization on of capital and surplus generation. This sub-sector also provides vital milling services to the majority of the low income population in both rural and small towns. The custom mills' flexibility in terms of relatively low initial investment costs and operational manageability provide an additional incentive for the development of the Tanzanian small scale entrepreneur. The implied linkage and income effects could be great, an aspect which is crucial in ensuring rural-urban balance.

In view of the fact that custom milling techniques and the small 24t.p.d. roller have the largest potential to generate employment opportunities and profits in both private and social terms, the decision taken by the NMC to expand its milling capacity on a large 120 t.p.d. roller was peverse. This inappropriate decision is largely reflected a number of cumulative forces reinforcing each other. Such forces include the 'engineering man' and 'empire building' type of factors (i.e., product quality and rate engineering efficiency) which make decision makers insensitive to cost minimization goals; the

preponderance of foreign experts and aid donors' influence in technology choice decision making process; misguided government policies and the whole macro-policy environment which has tended to discriminate against custom mills; and finally, lack of an indigenous technological capability.

An important policy implication emerging out the study is that government can play an important role in influencing the selection of appropriate technology. In this case study a neutral macro-policy environment for both custom and merchant mills could be desirable for it would make custom mills even better in terms of the overall competitiveness. But given NMC's insensitivity to cost minimization, the government might intervene directly (as it did in the case of superior sembe product) by banning the use of relatively inefficient 50 and 120t.p.d. rollers. Recently, the Tanzanian government have taken some steps which seem to be encouraging the development of the custom milling sub-sector. One would expect for example that the restoration of cooperatives with full responsibility for crop procurement, storage and delivery to marketing centres, would over time, reduce the monopoly power of NMC in terms of accessibility to raw grains. Some of the cooperatives have in fact, already embarked on custom milling thus posing a potential challenge to the NMC. In other words the composition of units has changed. In addition, the ban on private shipments of grain between regions has been lifted promising more accessibility to supply of grains by custom mills. Also, of some interest, has been the introduction of the crawling peg in order to correct for

the overvaluation of the exchange rate. Of course the full impact of these developments is likely to take some time before it is realized.

Finally, it should be noted that the grain-milling industry in Tanzania has built up over years, a technological structure which is not homogenous in terms of machine characteristics. Even within each subsector there are marked differences in models, vintages, rated capacities and sourcing of equipment. These differences have been associated with wide variations in factor intensities and operating performance suggesting some degree of flexibility in technological options. Despite this increased flexibility, the multiplicity of makes and models make it difficult and more expensive to shop around various suppliers since equipment parts and accessories may not be interchangeable. There may be need therefore, for the Tanzanian government to design a programme that will facilitate a more homogeneous capital structure.

NOTES

1. See for example Dhalman and Westphal (1982), Pickett (1977) and White (1978) among others.

2. This view is also shared by Fransman (1986) and Sen (1980).

3. If the initial investment cost of a project is (K), and if the projects lasts for (n) years and the rate of discount(r) is known then the initial investment (K) can be converted into a series of equip annual capital charge (R) by using the annuity formula i.e.,

$$R = K \frac{r\ (2+n)^{n}}{(1+n)^{n-1}}.$$

4. An important limitation of cross sectional data obtained from existing plants is that they preclude a wide range of potential techniques currently available on the market but are not presently in use in Tanzania.

5. The debilitating conceptual and measurement defects involved in the use of production functions have been widely discussed in the literature. See for example the survey by White (1978).

6. In 1984, the primary responsibility for crop procurement storage and delivery to marketing centres were restored to cooperatives.

7. The Engelberg huller consists of a steel cylindrical fluted roller revolving on a horizontal axis inside a sheath casing. The rubber roller sheller has two closely spaced rubber rollers rotating in opposite directions and at different speeds.

8. The price of a 24 t.p.d. maize roller was just a quarter of the 120 t.p.d. roller. The smallest roller mill employed 20 persons while the largest roller mill employed 61 persons. The larger roller was however, more capital intensive requiring Shs. 5.4 more to maintain one man-hour of operation than required by the small roller.

9. In the Chenery et.al (1961) equation the elasticity of substitution (e_s is indirectly estimated from the marginal productivity relation:

$$\ln (Q/L) = a + e_s \ln w + u$$

when Q is output (in tons), L is labour (in man hours) w is the wage rate and us is the error term. Kmenta's unrestricted CES equation is estimated by:

$$\ln Q = b_0 + b_1 \ln K + b_2 \ln L + b_3 (\ln K - \ln L)^2 + u.$$

10. Empirical tests for differences in production functions were further carried out using first, the Cobb-Douglas production function for custom and merchant mills by allowing the various parameters to varry between the two sub-sectors and secondly the trancedental logarithmic function (trans-log). The results were inconclusive however, because of insignificant coefficients. There was a degree of freedom problem in the former case and apparently the trans-log function was highly susceptible to multicollinearity because of the cross terms.

11. To obtain meaningful comparisons, both the capital-labour and capital-out ratios have been adjusted to levels that would hold if all firms worked the same number of shifts. This however, does not eliminate all theoretical and empirical problems surrounding the various measures of labour intensity as widely discussed in the literature. See for example Bhalla (1975) who presents an illuminating discussion on these problems.

12. Foreign exchange costs for a 120 t.p.d. maize roller were estimated to be Shs. 6 million, those for an imported 6 t.p.d. hammer mill were Shs. 54,200 and Shs. 27,100 for a local 6 t.p.d. hammer mill.

13. The estimating equation in the Cobb-Douglas production function was specified as

$$\ln Q = \ln A + b_1 \ln K + b_2 \ln L + u$$

(notations are as specified in 9 above).

14. See for example the case of Sierra Leone by King and Byerlee (1978).

15. From note (3) the annual capital recovery factor

c is defined as $c = \dfrac{r\,(1+r)^n}{(1+r)^{n-1}}$

16. See the feasibility study undertaken by NMC by the Tanzania Industrial Studies and Consulting Organisation - TISCO (1931:8).

17. See for example Alange (1987) and James (1987).

18. See for example studies by Bagachwa (1987), James (1987), Mlawa (1983), Skarstein and Wangwe (1986) and Williams (1975).

REFERENCES

Alange, S., (1987). "Acquisition Capabilities Through International Technology Transfer: The Case of Small Scale Industries in Tanzania". Ph.D. Thesis Chalmers University of Technology.

Bagachwa, M.S.D., (1987). "Choice of Technology in Grain-milling Industry in Tanzania". Dar es Salaam (mimeo).

Bhalla, A.S. (ed.), 1975). Technology and Employment in Industry. Geneva: ILO.

Dhalman, C.J. and L. Westphal, (1982). "Technological Effort in Industrial Development A Survey", in Stewart and James (1982).

Fransman, M., (1986). Technology and Economic Development. Brighton: Wheatsheaf Books.

James, J., (1987). "The Choice of Technology in Public Enterprise: A Comperative Study of Manufacturing Industry in Kenya and Tanzania". In Stewart (ed.), (1987), pp, 219 - 247.

Kaldor, N., (1978). Further Essays on Applied Economics. London: Duckworth.

King, R.P. and D. Byerlee, (1978). "Factor Intensities and Locational Linkages and Rural Consumption Patterns in Sierra-Leone". American Journal of Agricultural Economics, May, PP. 197-206.

Marketing Development Bureau - MDB, (1983). Price Policy Recommendations for the 1984 Agricultural Price Review. Ministry of Agriculture, Dar es Salaam.

Mlawa, H.M., (1983). The Acquisition of Technological Capability and Technical Change: A Study of Textile Industry in Tanzania". Doctoral Dissertation, University of Sussex.

National Milling Corporation - NMC, (1971). Annual Report and Accounts. Dar es Salaam.

Pickett, J., (1977). "The Work of Livingstone Institute on 'Appropriate' Technology - Editors Introduction". World Development, Vol. 5, pp. 773-776.

Schumacher, E.F., (1973). Small is Beautiful. A Study of Economics as if People Mattered. New York: Harper and Row.

Sen, A., (1980). "Labour and Technology", in J. Cody, H. Hughes and D. Wall (eds.), Policies for Industrial Progress in Developing Countries. London: Oxford University Press.

Skarstein, R. and S.M. Wangwe, (1986). Industrial Development in Tanzania: Some Critical Issues. Upsalla and Dar es Salaam: Institute of Development Studies and Tanzania Publishing House.

Stewart, F., (1977). Technology and Underdevelopment. New York: MacMillan.

Stewart, F., (ed.) (1987). Macro - Policies for Appropriate Technology in Developing Countries. Boulder and London: Westview Press.

Stewart F., and J. James, (eds.), 1982). The Economics of New Technology in Developing Countries. London: Frances Pinter.

Tanzania, United Republic of - URT, 1976). Third Five Year Plan for Economic and Social Development 1st July - 30th June, 1981. Dar es Salaam: National Printing Co.

TISCO, (1981). "Maize Mill at Korogwe". Report to National Milling Corporation, Dar es Salaam.

Wells, L.T., (1973). "Economic Man and Engineering Man: a Choice of Technology in a Low Wage Country". Public Policy, 21.

White, R.J., (1978). "The Evidence on Appropriate Factor Proportions for Manufacturing in Less Developed Countries": A Survey". Economic Development and Cultural Change, Vol. 27. pp. 27-50.

Williams D., (1975). "National Planning and Choice of Technology: The Case of Textiles in Tanzania". Economic Research Bureau Paper No. 75.12, Dar es Salaam.

Winston, G.C., (1979). "The Appeal of Inappropriate Technologies: Self Inflicted Wages, Ethnic Pride and Corruption". World Development, Vol. 7, pp. 835-845.

World Bank, (1981). "Tanzania Grain Storage and Milling Project". Staff Appraisal Report No. 26930. Washington, D.C.

Table 1. Employment and Capital Requirements

	Average Employment (number of workers)		Initial Fixed Cost (Sh.000)	Fixed Costs Per Manhour	Total Capital[1] Shs. Per Manhour
	Total	(Skilled)			
Maize Hammer					
4 t.p.d.	3	(0)	105.4	1.2	1.3
8 t.p.d.	4	(0)	297.7	2.1	2.2
22.5 t.p.d	8	(0)	259.5	3.6	3.8
Maize Roller					
24 t.p.d.	20	(3)	2569.5	11.0	11.8
50 t.p.d.	39	(11)	5886.6	13.0	13.9
120 t.p.d.	61	(14)	9230.0	16.4	18.4
Rice Huller					
4-8 t.p.d.	3	0	93.0	2.2	2.4
Rice Roller					
24 t.p.d.	17	(2)	1752.5	12.4	14.3
60 t.p.d.	37	(5)	4410.0	10.7	11.9
120 t.p.d.	51	(13)	7927.0	14.5	16.7

Source: Survey Data

Note: 1. Fixed capital + working capital

Table 2. Monthly Manhour Requirements in Materials Handling Section

Job	Manual Feeding Process (Unskilled)		Semi-Automatic Feeding Process (Unskilled)		Automatic Feeding Process (Unskilled)	
	Casual	Permanent	Casual	Permanent	Casual	Permanent
Unloading	768	-	768	-	192	-
Stacking	768	-	-	-	-	-
Destacking Slitting and Feeding	-	1,344	-	1,344	-	-
	1,536	1,344	768	1,344	192	-

Source: NMC.

Table 3. Equipment Cost and Labour Requirements in the Packing Section

Packing System	Equipment Cost (Shs. 000)	Daily Labour Skilled	Requirements: Unskilled
Manual	79	-	30
Semi-Automatic	10,200	3	6
Automatic	15,780	3	-

Source: NMC.

Table 4. Nutrient Composition of Different Maize Meals
(Per 100 gms of flour)

	Fully Sifted Meal (Sembe Superior)	Partially Sifted Meal (Sembe Standard)	Wholemeal (Dona)
Calories	363	360	356
Protein (%)	9.40	9.3	9.5
Calcium (mg)	5.00	6.00	7.0
Iron (mg)	1.2	1.8	2.3
Thiamin (Vit.B_1) mg	1.18	0.09	0.45
Riboflavin (Vit.B_2) mg	0.08	0.09	0.11
Niacin mg	0.60	1.30	2.00

Source: Uhlig and Bhat (1979: 18)

Note: ( ) Tanzania meal equivalent.

Table 5. Capital Requirements Per Unit of Output

	Capital	
	Fixed Shs./ton	Total Shs./ton
Maize Hammer		
4-8 t.p.d.	4.95	5.40
8.5-15 t.p.d.	5.88	6.40
24 t.p.d.	26.10	30.0
Maize Roller		
24 t.p.d.	57.40	61.40
50 t.p.d.	71.90	76.90
120 t.p.d.	61.90	80.50
Rice Huller		
4-8 t.p.d.	5.55	6.00
Rice Roller		
24 t.p.d.	39.50	45.40
60 t.p.d.	48.70	54.50
120 t.p.d.	48.90	56.20

Source: Survey Data

Note: Total Capital = Fixed + Working Capital.

Table 6. Benefit-Cost Ratios

	MARKET PRICES					SHADOW PRICES
	R = 10%		R = 15%			
	Current Capacity	Full Capacity	Current Capacity	50% Capacity	Full Capacity	Full Capacity
Hammer mill: 6 t.p.d.						
Electric-Imported	2.04	7.46	1.55	1.55	5.65	3.22
Electric - Local	2.25	6.93	1.70	1.44	5.22	3.27
Diesel-Imported	1.78	5.88	1.35	1.14	4.43	2.58
Diesel-Local	1.36	5.66	1.03	1.51	4.29	2.67
Hammer mill: 22.5 t.p.d.						
Electric-Imported	6.26	12.79	3.93	2.22	9.63	5.59
Electric-Local	6.05	12.42	3.79	2.00	9.29	7.18
Maize Rollers:						
All electric & Imported						
24 t.p.d.	1.49	2.51	1.01	0.46	1.82	0.79
50 t.p.d.	1.61	2.06	1.17	0.36	1.49	0.78
120 t.p.d.	1.12	2.04	0.81	0.31	1.48	0.77
Rice Hummer 6 t.p.d.						
Electric-Imported	3.45	14.54	2.60	4.10	10.95	7.94
Diesel-Imported	2.97	12.98	2.24	3.79	9.78	7.07
Rice Rubber Rollers						
All electric Imported						
24.t.p.d.	1.31	3.88	0.95	0.89	3.46	2.52
60 t.p.d.	1.55	3.38	1.14	0.76	2.45	1.69
120 top.d.	1.16	3.03	0.85	0.70	2.19	1.50

Sources: Survey Data.