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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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IMPACT OF DIFFERENT SUGAR TECHNOLOGIES ON THE ECONOMIC ENVIRONMENT[1/]

by

R. Alpine*

* Senior Lecturer, David Livingstone Institute, University of Strathclyde, Glasgow, U.K.

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INTRODUCTION

The performance of large scale vacuum pan and small scale open pan sulphitation (OPS) technology has been analysed in two companion papers, (1) and (2) respectively, in the context of a variety of African conditions. This paper extends the analysis by comparing the broader economic implications that appear to be associated with these technologies. Chapter I commences with an examination of the relative micro-economic performance of the various models developed in the papers referred to above, and continues by considering the employment generation effect of certain selected models. Further economic linkages are discussed in chapter II. Chapter III provides a contrast between the technologies in a social cost-benefit context, by means of shadow pricing certain important parameters. Finally chapter IV briefly considers the two technologies, for given scale of production, in terms of transport cost per tonne of sugar.

I. SUGAR PRODUCTION MODELS COMPARED

Sugar technology performance is analysed in papers (1) and (2) in relation to a variety of scenarios, which may principally be classified by length of crushing season (270 day 'long' season and 150 day 'short' season) and by scale of operation (100 tch and 200 tch for large scale, 100 tcd and 150 tcd for small scale) in terms of tonnes of cane per hour (tch) or per day (tcd) crushing capacity. In addition the climatic setting for the analysis of large scale technology was divided into the absence or presence of the need for irrigation of cane, There are, therefore, 8 different models analysed in paper (1), and 4 in paper (2), considered from a technical viewpoint.

The results generated by these models depend also on economic parameters. For simplicity, the prices of both inputs and outputs are classified into only two situations, described as 'low price' and 'high price' regimes. Further generation of results can be obtained by considering any combination of low and high prices. For convenience the results given in papers (1) and (2) are reproduced in Annex 1. In general one can say that, given the technical and economic parameter values underlying the calculations, profitability increases with length of crushing season, is higher in irrigated situations (reflecting the assumed considerable increase in cane yields), and increases (for each technology) with scale of operation.

A. Net present values

A comparison of the large and small scale technologies (for the long season situations) is easier if the results are converted to a per tonne of sugar per annum basis, as shown in Table 1 below. Calculations for the OPS technology are based on total sugar output, irrespective of quality, and are thus slightly higher than would be the case if allowance was made for the lower sucrose content of the 3rd sugar in particular - but this argument can be countered by the higher nuitritive value of 3rd sugar.

Table 1 Net present values per tonne of sugar per annum $

Long season rainfed	Discounted at	low prices 10%	high prices 10%	high prices 12%
100 tch		-91	556	310
200 tch		215	1127	760
100 tcd		-141	396	211
150 tcd		-11	610	419

A small change in the rate of discount in the more profitable high price situations can be seen to have little effect on relative performance beyond raising slightly the position of both the 200 tch and 150 tcd models. In the short season rainfed situations, a broadly similar set of results would obtain, although at the chosen discount rate (10%) all NPVs are negative.

Capital requirements for large scale sugar projects are considerable, particularly in relation to the annual investment expenditure (public and private) of many developing African countries. For this reason it is argued, as in reference (3), that comparison of profitability of technologies ought to take the size of capital investment into account: specifically that comparison should run in terms of NPV per unit of investment, NPV/K, where K measures the discounted sum of fixed capital invested (discounted since it usually is spread over a number of years). Table 2 shows the discounted fixed capital requirements for each rainfed situation model: the figures for the irrigated situation models are less than 2% higher than the corresponding rainfed situation figure.

Table 2 Fixed capital requirements in terms of present value+

	100 tch		200 tch		100 tcd		150 tcd	
	long season	short season	long season	short season	long season	short season	long season	short season
low prices	31.94	31.99	54.51	54.00	0.41	0.42	0.51	0.52
high prices	48.73	48.63	83.56	82.05	0.60	0.61	0.76	0.77

+ $ million discounted at 10% p.a.

The capital requirements for short season situations are slightly higher than the long season counterparts (when expenditures are discounted) on account of the shorter time interval before sugar production commences. The corresponding NPV calculations take into account, of course, the fact that revenues are earned one year earlier.

Table 3 provides information on NPV/K for each of the long season rainfed situations. The ordering of the results appears very similar to that obtained in Table 1, except that the small scale models improve in relation to the others at high prices and in fact the 150 tcd model marginally outperforms the 200 tch model.

Table 3		NPV ÷ K		(ß)
	100 tch	200 tch	100 tcd	150 tcd
low prices	-0.16	0.43	-0.45	-0.04
high prices	0.63	1.48	0.86	1.57

B. Employment generation

A commonly used device in comparing large and small scale technologies, for example with reference to sugar see (4), is to calculate the number of small scale factories that are equivalent (in terms of either sugar output or capital input) to one large scale factory. The present work reported here goes beyond the factory stage of production: nevertheless the basis for comparison has merit and may usefully be employed here, in terms of the combined agricultural and factory stages for the long season rainfed situation.

The sugar output from 28 150 tcd factories would exactly equal that of a single 100 tch factory. The total discounted fixed capital cost of these units would amount to ß14.28 million (compared with ß31.94 million for the 100 tch factory). Factory employment would be 7,364 (compared with 464) excluding administrative employees.

The required cane area to support these small units would amount to 18,620 hectares (compared with 9,058 hectares): the agricultural employment generated is based in the small scale models on an estimate of 1 person per 3 hectares (cultivation) plus 1 person per 4 hectares (harvesting) giving a total of 10,860 persons. The corresponding total for a 100 tch factory is estimated at approximately 3,000.

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Finally, 336 people would be employed in administration, at 12 per OPS unit, against 150 in the 100 tch factory. Thus total employment in OPS units would equal 18,560 compared with approximately 3,600 required to serve a single 100 tch factory.

A comparison of these results with the corresponding figures obtained if attention is paid to the factory stage only shows that the OPS capital requirement rises from 28% to 45% that of the 100 tch model once the agricultural stage is taken into account whilst the labour requirement falls from 1,587% to 516% that of the 100 tch factory.

A similar comparison between 56 OPS units and a single 200 tch factory shows the OPS capital requirement to be 52% that of the large factory, whilst the labour requirement is 588%.

The skilled labour requirements of the OPS units are not, however, so much greater than those of a single large scale factory, based on a definition of skilled labour to include craftsmen plus supervisory and managerial grades. On the estimates given in papers (1) and (2), the number of skilled employees required on the sugar production side (technical plus processing) is 12 per OPS unit compared with 149 and 179 for the 100 tch and 200 tch factories respectively. Agricultural and administrative requirements for the large scale factories, in comparison with the small number required per OPS unit, greatly reduces this imbalance: overall requirements of skilled personnel are estimated at 352 and 477 for the two large factories respectively and 20 per OPS unit. The relatively greater agricultural requirements for skilled labour by large factories are partly explained by the higher degree of mechanisation, implying more maintenance mechanics, partly by the greater amount of supervision likely to be needed by large scale agriculture.

II. SUGAR TECHNOLOGY LINKAGES

The social cost benefit analysis carried out in chapter III is based on shadow pricing of a number of inputs and outputs directly connected with sugar production. It can happen, however, that costs and benefits result from a project without accruing directly to it, and the project analyst has then to consider whether or not to introduce these externalities into the calculations. In principle a number of such externalities might arise in the course of sugar production.

There are two major areas where a sugar project might yield external benefits to an economy resulting from its input requirements. Firstly an indigenous engineering industry might develop in order to produce pieces of equipment and spare parts. Secondly the project's needs for skilled manpower are likely to be such, in relation to available supply, that a considerable training effort will be undertaken.

Given the relatively low level of industrialisation in many developing countries it is worth considering whether or not a new industrial (or agro-industrial) project will further the process of industrialisation or have to import all the required equipment throughout the project life. Even when the benefit from the project in terms of foreign exchange saving outweigh the additional import requirement for replacement capital the latter course means that a stage in the development process has not been reinforced.

Vacuum pan factory plant and equipment in developing African countries is almost entirely imported; similarly spare parts are very largely purchased from developed countries. A change in this situation would seem to require either the emergence of an indigenous engineering industry with proven quality control standards or the creation of suitably large workshop facilities within the sugar industry itself. This latter option does seem potentially possible (technically) at present in certain countries: it may be commercially attractive in countries where spare parts are highly taxed or subject to considerable delay in transit, but usually the scale of production of individual parts to serve a few factories is insufficiently high for economies of scale to be enjoyed - and this may be an important factor in deterring outside suppliers too.

In the case of OPS units the proportion of equipment which may be manufactured domestically seems potentially promising. Expenditure on tanks, heating bels and furnaces comprises about 25% of the FOB value of plant and equipment, whilst filter presses and crystallisers account for a further 25%. Given the relatively low value to bulk density of these items it ought to be practical for domestic manufacturers to produce them at or below their CIF price. Hence it can be expected, depending on the status of the engineering industry, that up to 35% of the equipment (allowing for imported materials) might be manufactured locally, at least within a few years of the introduction of such plants.

In well managed vacuum pan factories it is customary to find training programmes organised within the factory, both to up grade employees (from unskilled to semi-skilled, for example) and to produce supervisory staff. The opportunity cost of employees trained within the project is the rate they were previously earning (as unskilled labour for example).

Instead of reducing the market wage now being paid to a shadow wage rate reflecting opportunity cost (as is done for unskilled labour employed by the project in chapter III), internally trained employees can be priced at the market wage rates paid to them and the value of training appear as an additional benefit. This latter approach is adopted in this paper, in order to illustrate the benefit which training can yield.

The internal benefit of training is based on the following assumptions: (i) that semi-skilled employees, trained on the job, have a social opportunity cost equal to that of unskilled employees; (ii) that skilled workers have a social opportunity cost 25% below the market cost of employing them; (iii) that supervisory staff also have a social opportunity equal to 75% of the market cost of skilled workers. The estimate of the social benefit of training is thus the difference between the market cost and the social opportunity cost, and this is calculated (on a discounted cash flow basis) over the project life. The present value of training, discounted at 10% per annum, is given as $2.35 million for the 100 tch long season rainfed model and $4.00 million for the corresponding 200 tch model.

A sugar project can also introduce linkages on the output side, when one of its by-products is used in further processing. The scope for such utilisation is discussed in reference (5). When such opportunity exists it implies that the by-product's value is increased and so the benefit from the linkage can at least theoretically be introduced into the sugar project calculation. In practice it can be diffiuclt to obtain an accurate estimate of the social value of the by product without also undertaking a full appraisal of the user project.

In situations when cane is supplied by outgrowers the potential for externalities further increase. In principle association with modern farming techniques can lead to changes in production methods used with traditional crops: increased yields through fertiliser application is one example, particularly if cane supply substantially raises the level of farm income so that finance is readily available. On the other hand the long lead time (especially in long season situations) between planting and harvesting, and the fact that land clearance, preparation etc. is necessary at the start of the cane cycle means that cane payments are received infrequently (in large amounts) and lag expenditures by several months. Handling this financial situation is a task which requires certain financial sophistication if maximum benefit is to be enjoyed.

III. SHADOW PRICING

The calculations presented in chapter I are based on market prices as observed in a number of African countries. It is well known that such prices can differ, sometimes substantially, from the prices that would correctly reflect a country's supply of resources and social preferences. Use of market prices in project evaluation is necessary, at least as a first step, in order to examine the profitability of the project for the firm or firms which undertake it, but consideration of the contribution which the project can make to the country's social welfare requires that evaluation is carried out in social (or shadow) prices.

In essence shadow prices should be such that input prices reflect social opportunity cost of using the inputs for the particular purpose and output prices reflect the utility which the user of the output receives. Measurement of shadow prices is in practice often difficult, requiring substantial information beyond that pertaining to the project. For present purposes, given the generality of the price data, a few simplifying assumptions are in order. In consideration of projects relating to particular countries more specific calculations are usually desirable.

The variables for which alternative, shadow, prices are used have been selected to reflect the more common distortions to be found in many developing countries: these relate to the prices for labour, fuel and foreign exchange.

Labour requirements are subdivided into unskilled labour, which receives a basic minimum wage (often set by Government statute), and other labour which receives a premium reflecting at least to some extent the relative scarcity of trained people. In chapter II it was stated that the payment to the latter category of employee would not be adjusted (downwards) in the social cost benefit calculation, but instead the value of training used as a measure of the additional benefit which training provides. The shadow wage for unskilled labour is taken as 50% of the market wage.

Taxation of inputs used by sugar factories varies considerably from country to country, but for most industrial inputs except those associated with road transport vehicles (cars, pick-ups etc) tax levied is not large. For simplicity it is assumed here that tax is levied on only three items, viz. vehicles as defined above, fuel consumed by these vehicles and housing equipment, as shown in Table 4 overleaf.

It is not uncommon in developing countries for foreign exchange to be undervalued with the consequent excess demand for it blocked by use of controls of various kinds. Such a situation is not surprising, especially if many of the capital goods and a number of important raw materials/ intermediate goods have to be imported whereas export earnings are based on a narrow range of commodities. It is assumed here that the shadow exchange rate (if tariffs, import controls etc. were abolished) would be 50% greater than the official rate (i.e. the shadow price of imported goods is 50% higher than the market price).

In order to determine the conversion factor for the various inputs it is necessary to specify import and tax contents etc and this data also appears in Table 4.

The impact of these price corrections on various categories of expenditure is shown in Annex tables II and III, which provide conversion factors for the agricultural and factory expenditures as itemised in papers (1) and (2). The factors are obtained from an analysis of the relative weights to be attached to the various items whose own conversion factors are shown in Table 4.

Table 4 Shadow prices for selected inputs

Parameter	Conversion factor	Item of expenditure (%)					
		Equipment	Vehicles	Housing	Transport fuel	Other fuel and chemicals	Other factory materials
Import content	1.5	90	63	20	50	90	30
Tax	0		30	10	40		
Unskilled labour	0.5			15			
Skilled labour/ Other local expenditure	1	10	7	35	10	10	70
Shadow price/ market price		1.45	1.01	0.95	0.85	1.45	1.13

The other major area where consideration of price correction is important is in the calculation of revenue. In papers (1) and (2), sugar is priced at $300 per tonne (low price) and $600 per tonne (high price). At present the world market price for refined sugar, CIF African ports, is around $260 per tonne. Most long term sugar transactions are settled at prices above the prevailing world market price and even without allowing for the possibility that the present world price is below its equilibrium trend price it would seem reasonable to take $300 per tonne as the CIF price for sugar in Africa: adjusting for an overvalued exchange rate implies a shadow price of $450 per tonne ex factory, if it is assumed that internal distribution cost from the factory is the same as that from the port. This price for sugar is used in both low and high price models.

The shadow price for molasses is increased by 50% to represent the effect of the shadow exchange rate. In the papers quoted, the molasses price was already based on the world market price.

Application of the shadow prices and resulting conversion factors to the calculations undertaken to measure private profitability shows a considerable change in the results for the various models. Firstly, because the shadow price for sugar is 25% below the market price, all short season models now show considerable losses. For example in the 200 tch rainfed model, the NPV at high prices falls from - ฿26.8 million to - ฿137.3 million, and the project even fails to achieve a surplus of revenue over direct operating cost. Attention is therefore focussed on a comparison of large scale and small scale units in the long season situations, given in Table 5 below.

Table 5 Long season rainfed	Measures of social profitability 1/		
	NPV 2/ ฿ million	IRR %	NPV per tsa 3/ ฿
100 tch	29.75	15.5	541
200 tch	97.45	20.1	886
100 tcd	1.01	22.1	768
150 tcd	1.84	26.3	935

1/ Measured at low prices

2/ Discounted at 10% per annum

3/ Tonnes of sugar per annum

Comparison with the corresponding results for private profitability in Annex I shows that social returns are higher, given the shadow price conversion factors, than private returns. In addition, social returns from small scale units are now higher than those from large scale factories. Closer examination of this result reveals that this relative improvement is due largely to the following points:

(i) agricultural and factory operating costs at social prices are slightly lower in the case of 150 tcd OPS units than at private prices, whereas in the 200 tch factory model they are approximately 20% higher;

(ii) total fixed caiital requirements at social instead of private prices increase by 27.5% in the case of 150 tcd units compared with a rise of 31.6% for the 200 tch model.

IV. SUGAR DISTRIBUTION

The analysis contained in papers (1) and (2) has concentrated on sugar production. Since 90% or more of sugar consumption in most developing countries is by households, it is important to consider also the distribution stage. One problem in attempting to model this aspect concerns the extent to which movement of sugar is controlled by Government intervention, partly because of the high taxation that often is imposed, partly because of relative scarcity in available supply. Analysis here concentrates on a fairly simple situation, which nevertheless throws light on relative transport costs.

By combining data on sugar consumption per head and population density one can estimate the area that would be served by factories with given sugar outputs. Thus a 150 tcd unit operating in a long season situation produces 1965 tonnes of sugar. If population density around this unit is 100 per km^2 and the population has a sugar consumption of 10 kg per head then this unit can serve an area given by a circle of approximately 25 km radius. For sake of simplicity it is assumed that the average trip length (to distribute the sugar) is equal to the radius: if the population were uniformly distributed throughout the area and each distribution could be done in a straight line ('as the crow flies') then the average trip length would be $\frac{2}{3}$ of the radius. Given a transport cost of $ 0.05 per tonne kilometre, this implies a transport cost of $1.25 per tonne of sugar.

Calculations similar to that outlined above have been made on the basis of 3 values for each of sugar consumption per head and population density for 3 long season models (150 tcd, 100 tch and 200 tch), evaluated at a transport cost of $0.05 per tonne km. These results are shown in Annex IV. For the same parameter values as used above, the corresponding transport costs per tonne of sugar are $6.62 (100 tch) and $9.36 (200 tch).

In practice, sugar distribution will depend on how sugar consumption per head varies from region to region within a country: usually in developing countries per capita consumption in urban areas is several times the national average and sometimes consumption in rural areas is close to zero. In this case the transport of sugar will be more concentrated (for example by rail at a lower cost per tonne km), so that the figures given in Annex IV should be seen as representing the maximum gap between small scale and large scale situations.

The differential transport cost (for consumption of 10 kg per head and population density of 100 per km^2) between a 150 tcd factory and a 200 tch factory is $8.1 per tonne. The discounted present value of $8.1 per tonne of sugar produced by a 200 tch factory over 25 years (110,000 tonnes per annum) is approximately $6 million: this figure thus represents the maximum additional transport cost associated with concentrating production at a single site in the most unfavourable circumstance (when population and can growing areas are uniformly distributed throughout an entire country).

ANNEX I

Net present values and internal rates of return

		Annual Sugar production 000 tonnes	low prices NPV[1/] ₿ million	low prices IRR %	high prices NPV[1/] ₿ million	high prices IRR %
Large scale vacuum pan						
1. 100 tch						
Long season	rainfed	55.0	-5.0	8.7	30.6	15.0
	irrigated	55.0	7.2	11.7	53.8	17.3
Short season	rainfed	30.5	-41.5	loss making	-40.3	1.9
	irrigated	30.5	-26.3	0.9	-18.1	6.5
2. 200 tch						
Long season	rainfed	110.0	23.7	13.4	124.0	20.2
	irrigated	110.0	48.0	16.1	164.9	22.2
Short season	rainfed	61.0	-48.5	0.7	-26.8	7.1
	irrigated	61.0	-20.2	6.4	19.1	12.0
Small scale open pan						
1. 100 tcd						
Long season	rainfed	1.31	-0.19	6.5	0.52	15.4
Short season	rainfed	0.73	-0.93	loss making	-1.07	loss making
2. 150 tcd						
Long season	rainfed	1.97	-0.02	9.5	1.20	18.9

ANNEX I cont'd

	Annual Sugar production	low prices		high prices	
		NPV 1/	IRR	NPV 1/	IRR
	000 tonnes	$ million	%	$ million	%
Short season rainfed	1.09	-1.12	loss making	-1.15	loss making

1/ Discounted at 10% per annum.

ANNEX II

Conversion factors for large scale agricultural and factory expenditures

Activity	Conversion factor
1. Agriculture	
(a) land clearance/road construction	0.97
(b) land preparation/planting	1.08
plant/ratoon cultivation	1.24
civil engineering	1.13
harvesting: long season	1.10
short season	1.07
administration	1.05
2. Factory	
(a) installation/civil works	1.18
(b) managerial staff/skilled and semi skilled	1.00
unskilled/labour	0.50
process materials	1.17
repairs and replacement materials	1.40
fuel	1.32
miscellaneous	1.11
3. Administration	
operation cost	1.00

ANNEX III

Conversion factors for small scale agricultural and factory expenditures

Activity	Conversion factor
1. Agriculture	
(a) land clearance/road construction	0.85
(b) land preparation/planting	1.00
plant crop cultivation	0.98
ratoon crop cultivation	0.60
civil engineering	0.70
harvesting	0.95
administration	1.00
2. Factory	
(a) installation/civil works	1.18
initial training	1.50
(b) managerial staff/skilled labour	1.00
unskilled/semi skilled labour	0.50
process materials	1.24
repairs and replacement materials	1.35
fuel	1.40
miscellaneous	1.00

ANNEX IV

Transport cost per tonne of sugar ($)

	Sugar consumption per head		
	5kg	10kg	15kg
1. <u>150 tcd</u>			
population density per km^2			
40	2.8	2.0	1.6
100	1.8	1.3	1.0
250	1.1	0.8	0.6
2. <u>100 tch</u>			
40	14.8	10.5	8.5
100	9.4	6.6	5.4
250	5.9	4.2	3.4
3. <u>200 tch</u>			
40	20.9	14.8	12.1
100	13.2	9.4	7.6
250	8.4	5.9	4.8

REFERENCES

1. Alpine R. and Duguid Fiona, Economic Viability in African Conditions of the Large Scale Vacuum Pan Sugar Technology, paper presented at the UNEP/UNIDO Seminar on the Implication of Technology Choice in the African Sugar Industry, 18-22 April, 1977, Nairobi, Kenya.
2. Alpine R. and Duguid Fiona, Economic Viability in African Conditions of the Small Scale Open Pan Sugar Technology, paper presented at the UNEP/UNIDO Seminar, 18-22 April, 1977, Nairobi, Kenya.
3. Pickett J., A Report on a Pilot Investigation of the Choice of Technology in Developing Countries, University of Strathclyde, Glasgow, U.K., December 1975.
4. Baron C.G., Sugar Processing Techniques in India, in A.S. Bhalla (editor), Technology and Employment in Industry, ILO, Geneva, 1975.
5. Duguid Fiona and Alpine R., Possibilities for the Further Processing of Sugar Industry By-Products, paper presented at the UNEP/UNIDO Seminar, 18-22 April, 1977, Nairobi, Kenya.

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