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Choice of Techniques: A Case Study of the Cottonseed Oil-extraction Industry in Pakistan

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INTRODUCTION

This paper analyses the choice of techniques at the product level with a view to evaluating the claim made by Stewart [17] and others that "choice of technique is eliminated once choice of product is made". We consider the extraction of edible oil from cottonseed as a case study. Use is made of engineering data, coupled with product and factor price data from Pakistan, to examine the possibilities of factor substitution at the micro level for a reasonably well-defined product. The product in this case is well defined, although there are some qualitative differences associated with different methods of extraction.

The data available for analysis are *ex ante*. Thus, one can avoid the "putty-clay" argument generally advanced to explain the lack of choice of techniques in production.[1]

The analyses in this paper are of additional interest because they entail the examination of an actual feasibility study submitted by consultants, Experience Incorporated, to the Government of Pakistan. The paper also presents a description of Pakistan's edible oil industry and of the techniques currently employed to extract oil from seed. The analyses focus on the evaluation of four large-scale techniques for extracting cottonseed oil.[2]

CHOICE-OF-TECHNIQUE ANALYSES

This section considers the economic efficiency of techniques for oil extraction from cottonseed. In our analyses, all prices of products and inputs are taken as

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[1] Briefly stated, this argument claims that factor proportions are like "putty" before the techniques are installed, so that a choice of techniques is possible. However, once the techniques are installed, factor proportions are like "clay" and no choice of techniques is possible. See Winston [21].

[2] See Malik [11].

given. Most of the data used in this paper are from the feasibility report by Experience Incorporated [4], which is based on field surveys in Pakistan and engineering data from the United States of America. Although the report is very comprehensive, we do not agree with all its conclusions.

The data relate to low-pressure expellers with input of 100 tons of cottonseed per day, and to high-pressure expellers, direct-solvent extractors and pre-press extractors with input capacities of 500 tons of cottonseed per day.[3] The data for plants with a capacity of 500 tons per day are based on the assumption of 300 days of operation per year. For the low-pressure expellers, however, the data are presented for 190 days of operation per year. The consultants suggest that low-pressure expellers can be converted to a 300-day operation with the construction of seed storage houses. Data for such an operation are also provided.

The consultants used identical prices for raw materials, products and by-products for the different techniques. However, some of the techniques have by-products that command different prices in the market owing to traditional preferences and qualitative differences. This could result in a bias against techniques whose by-products command a premium price in the market.

The other source from which biases enter the analysis is that of engineering data on efficiencies. The efficiency rates used are those quoted by the manufacturers and there is no way of checking them in the absence of data from alternative sources. Even if such data were available, it becomes difficult to disentangle the web of engineering details to get data on comparable plants. There are components of the processes regarding whose requirements and specifications even engineers do not agree.

The data from Experience Incorporated [4] are used in our analyses. Table 2 of their feasibility report lists the physical yields of products and by-products for the four techniques. Tables 4 and 5 state the cost assumptions and prices used in the feasibility study. Tables 8 and 11 give detailed operating cost and revenue statements for the four techniques. Tables A-1 to A-5 present the breakdown of capital costs. Table E-1 gives the working capital requirements of each technique.

An interesting point that needs to be highlighted at the outset is the size of the plants that have been evaluated by the consultants. One plant with a capacity of 500 tons per day would require cottonseed input of 150,000 tons for 300 days of operation in one year. This is nearly fifteen percent of the total availability of cottonseed in Pakistan in 1975-76, because the total production of cottonseed in that year was 1,011,000 tonnes [10; 12]. Thus, only seven such plants would have been required to handle the entire domestic production of cottonseed in 1975-76. Alternatively, it would have taken only 34 of the smaller low-pressure expellers (operating for 300 days) to handle the entire production of cottonseed in Pakistan in 1975-76. This has important employment implications. It is estimated that nearly 20,000 unskilled labourers were directly employed in the industry in that year [11; 13]. The unskilled labour requirements of operating seven plants with an input capacity of 500 tons each per day were estimated at 3,500 to 3,850 labourers, depending upon the technique being considered [4, Table 11]. This means that over 16,000 labourers would be directly displaced if the industry was converted to these techniques. In 1975-76, Pakistan did not have the techniques for processing edible oils on the scale described in [4]. The choice of this scale of production by the consultants rules out a range of smaller-scale techniques discussed in the previous section. As such, data on only four techniques are presented for evaluation. Given the historical process of development of techniques, scale of production and capital intensity are likely to be correlated. The consideration of feasibility studies such as the one in question, therefore, highlights one possible avenue through which developing countries make choices of capital-intensive techniques.

[3]The units of measurement in the feasibility study are imperial rather than metric. We use the imperial units in our subsequent discussion to facilitate references to the data in Experience Incorporated [4].

FACTOR – PRODUCTIVITY RATIOS

Suppose for a given technique, A, the ratios of output to capital and of output to labour are represented by $(O/K)_A$ and $(O/L)_A$ respectively. If for the two techniques A and B the inequality relationships $(O/K)_A > (O/K)_B$ and $(O/L)_A > (O/L)_B$ are true, then, *ceteris paribus*, it follows that Technique A is more efficient than Technique B. However, if only one of these two inequality relationships is true, then the prevailing factor prices are crucial for identifying the more efficient technique.

The factor – productivity ratios identify technical relationships between capital, labour and output, only if values of other factors are constant. Differing rates of capacity utilization, work shifts, technical progress and efficiency are factors that may have distortional effects. Moreover, the concept of output – capital ratio involves relating a flow of output to a stock of capital. To overcome this problem, we consider an annualized capital measure which is computed from the expected life of the plants and an appropriate discount rate.

Values of yearly outputs and inputs, output – factor ratios and capital – labour ratios are presented in Table 1 for the four techniques being considered for cottonseed oil extraction. These data are drawn directly from Tables 8 and 11 given in [4] for the values of output and inputs and the total labour requirements, and from Tables A-1 to A-5 of the same report for the total capital requirements. The data on value of output are the total sales figures in Tables 8 and 11, whilst the value of inputs are the cost of cottonseed plus total operating costs, net of insurance, taxes and depreciation. The data for the low-pressure expellers relate to plants capable of 300 days of operation per year. The capital data are the total capital requirements

Table 1

Values of Outputs, Inputs and Factor Productivities for Cottonseed-Processing Techniques

Variables	Pressure Expellers		Solvent Extractors	
	Low	High	Direct	Pre-press
Outputs and Inputs				
Value of Outputs (Rs 1,000)	48,720	248,215	237,135	239,431
Value of Inputs (Rs 1,000)	44,037	212,922	214,468	216,215
Capital (Rs 1,000)	37,968	123,251	131,398	146,974
Capital Annualized (Rs 1,000)	4,459	14,477	15,434	17,264
Labour (Number)	145	610	610	665
Output-factor Ratios				
Value of Outputs/Value of Inputs	1.106	1.166	1.106	1.107
Value of Inputs/Capital	1.283	2.014	1.805	1.629
Value of Outputs/Capital Annualized	10.926	17.145	15.364	13.869
Value of Outputs/Labour	336.000	406.910	388.750	360.050
Capital-labour Ratios				
Capital/Labour	261.850	202.050	215.410	222.520
Capital Annualized/Labour	30.752	23.733	25.302	25.961

Source: Based upon [4; Tables 8, 11 and A.1 – A.5].

for each technique, listed in Tables A-1 to A-5. The figures for the annualized value of capital were obtained by assuming a 20-year life of the plants and a 10-percent discount rate.

The output – input ratios for high-pressure expellers are the highest amongst the techniques compared. Moreover, as the high-pressure expellers also require smaller outlays of capital and labour per unit of ouput and have the smallest capital intensities for the four techniques, it follows that they are the most economically efficient techniques.

The absence of the trade-off between efficiency and employment for the four cottonseed-processing techniques can be clearly seen by calculating the capital and labour requirements for generating a unit of value added for each technique. This methodology, used by Timmer [19], can also be effectively employed in cases where it is necessary to use factor prices to identify the most efficient technique.

The amounts of annualized capital and labour required to generate 1,000 rupees of value added by the four techniques are presented in Table 2. Value added is the difference between the value of output and the value of inputs in Table 1. It is clear that high-pressure expellers dominate all other techniques. They require less capital and labour to generate the same value added.[4]

Table 2

Total Value Added per Year and Labour Required to Generate Rs 1,000 Value-added

Techniques	Value-added	Annualized Capital/ Value-added	Labour/ Value-added
Low-pressure Expeller	4,683	950	0.031
High-pressure Expeller	35,293	410	0.017
Direct Solvent Extractor	22,667	681	0.017
Pre-press Solvent Extractor	23,216	744	0.029

Source: Based upon [4. Tables 8, 11 and A.1 – A.5].

A trade-off would exist if low-pressure expellers and pre-press solvent extractors were the only ones from which to choose. In such a case, relative factor prices could be used to determine the optimal technique.

One obvious shortcoming of this approach, which becomes clear from the data set out in Table 2, is the assumption of constant returns to scale. This means that capital and labour requirements are assumed to increase in the same proportion as output (in this case capacity). This results in a bias against techniques with a smaller output (capacity) *vis-à-vis* the techniques for which data are available for larger capacity plants. Since low-pressure expellers are assumed to have a capacity of 100 tons per day, whereas the other three techniques have a capacity of 500 tons each per day, it suggests that capital and labour requirements would have to increase five-fold for the first technique to be comparable with the others. One method normally suggested is to increase the equipment costs by 1.5 times when output is doubled. This established engineering practice is generally advocated by consultants; see Experience Incorporated [4] and Timmer *et al.* [19]. The procedure, however, is *ad hoc* and Experience Incorporated does not explicitly state how it takes into account the increased labour requirements, which presumably would have to double to

[4] It is interesting to note that the value added from direct-extraction and pre-press extraction is negative if a more realistic cottonseed oil price of 165 rupees per maund, which was the import price of palm oil in 1975-76, is assumed. This would imply that the choice between techniques is really limited to low-pressure expellers and high-pressure expellers.

take into account the increased capacity. Moreover, the consultants have not used this rule when obtaining capital costs for the low-pressure expellers with capacity of 100 tons each per day. In fact, they use the cost of five plants with a capacity of 20 tons each per day; see Tables A-1 and A-2 of [4]. This is a serious shortcoming of the approach. Finally, as noted by Timmer [19], his approach is biased against labour-intensive techniques because the maintenance and operating costs required for the capital equipment are ignored.

BENEFIT – COST ANALYSIS

In this section we consider benefit – cost analyses[5] to compare the profitability of the four techniques over the years of their effective production.

Data from Experience Incoporated [4] are used to obtain cash flows for the four techniques. These are obtained from data in their Tables 8, 11, E-1 and A-1 to A-5.[6]

Detailed calculations for each of the twenty years of the expected life of the plants have been made. It is assumed that the plants require 21 months to construct. The capital costs are therefore apportioned between Year 1 and Year 2 in the ratio of 12.9. Production is assumed to start at the beginning of the last quarter of Year 2. It is assumed that 22 percent of all building costs and 10 percent of all installation costs are payments to unskilled labour. These percentages are suggested by Little and Mirrlees [10].

The operating costs include costs of seed plus total operating expenses less insurance, depreciation and taxes [4, Tables 8 & 11]. These latter costs are transfer payments. It is assumed that three percent of all maintenance costs and 24 percent of power costs are operating costs for unskilled labour [10]. Since production is assumed to start at the beginning of the last quarter of the second year, only 25 percent of the operating costs are charged for Year 2. From Year 3 onwards, full operating costs and total revenue, associated with full-capacity utilization and 300-day operation, are assumed. In addition to using the cottonseed oil price of 200 rupees per maund, as used in [4], we use the alternative price of 165 rupees per maund.

[5] There are two methods generally used for such analyses. The first method is due to Little and Mirrlees [10], and the second one, developed by Dasgupta, Marglin and Sen [3], is used by the United Nations Industrial Development Organization, and is commonly referred to as the UNIDO methodology. The two methods, however, differ basically in their choice of numeraire or unit of accounting. We have opted to use the UNIDO methodology, in which consumption is the numeraire for accounting. A detailed review of the differences can be found in Little and Mirrlees [10] and Dasgupta [2].

[6] These data have not been reproduced here because of space constraints. These are, however, available with the author.

Fifty percent of the working capital, listed in Table E-1 of [4], is assumed to be needed at the end of Year 1 and fifty percent at the end of Year 2, following the convention of Experience Incorporated [4]. At the end of the 20-year life of the plant, it is assumed that the plant's salvage value is equal to 20 percent of the total plant costs plus working capital. This salvage value is treated as a cash inflow in Year 20. Import duties, surcharge and insurance relating to the capital equipment are listed in the cash flow tables as a separate category and treated as a transfer payment. The land requirements for the four techniques are similar, and therefore are ignored in the analyses. It is noted that Experience Incorporated [4] ignore working capital and treat it as a transfer payment.

For each year, the net benefits are obtained by subtracting the costs from the benefits. The net benefits are based on the alternative cottonseed oils price of 165 rupees per maund.

Initially, net present values for the different techniques are obtained by using a 10-percent discount rate per year for the cash flows. The total net benefits and the net present values for the four techniques, under the two price assumptions, are presented in Table 3. It is evident that high-pressure expellers are the optimal technique for processing cottonseed. Discounting the net benefits at 10 percent leads to a yield of negative net present value for low-pressure expellers, implying that there would be a net loss to the economy from employing them if the inflation rate

Table 3

Total Net Benefits and Net Present Values for Different Techniques

Techniques	Total Net Benefits (Rs 1,000)	Net Present Values* (Rs 1,000)
Low-pressure Expeller	58,694 (–17,930)	–3,644 (–35,904)
High-pressure Expeller	557,340 (146,312)	129,534 (–43,506)
Direct Solvent Extractor	321,340 (–120,986)	25,878 (–160,340)
Pre-press Solvent Extractor	320,860 (–129,812)	17,665 (–72,064)

Source: Based upon [4, Tables A.1 – A.4].
Note: The net present values were obtained by discounting the net benefits at the ten percent level.
*The values in parentheses are for the alternative oil price of 165 rupees per maund.

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over 20 years was more than 10 percent. However, for the cottonseed oil price of 165 rupees per maund, the total net benefits are negative for all the techniques, except high-pressure expellers. Discounting the net benefits by 10 percent for this price of cottonseed oil yields negative net present values for all techniques, including high-pressure expellers. Given the lower price of cottonseed-oil, none of these techniques would be appropriate for Pakistan.

The economic cash flows are derived by adjusting for obvious market distortions. For a social analysis, each of the categories of traded materials, domestic materials, unskilled labour and skilled labour need to be evaluated at the cost incurred by, or the benefit accruing to, society (as an outcome of the production process), all measured in the appropriate numeraire or unit of account. The numeraire used in this analysis, aggregate consumption, is often taken as a rough measure of current welfare. In general, the producers' or consumers' willingness to pay is an adequate first approximation of the benefits and costs, unless there are obvious distortions in the market. Alternatively, if the inputs or the production of the project is substantial enough to affect the market price, the market demand function needs to be estimated to determine the willingness to pay for the commodity in question. In this case, however, the market price is used as a measure of the willingness to pay. This procedure was used for cottonseed and most of the by-products of cottonseed-oil processing which were non-traded. Linters are exported, but, due to the way cotton waste is listed in the Foreign Trade Statistics, it is difficult to obtain c.i.f. prices. For cottonseed meal and cake, c.i.f. prices are used. Soap stock is imported, but the f.o.b. price is not available. This tends to bias the results slightly in favour of solvent-extraction plants since they generate less soap stock and, hence, would contribute marginally less to foreign-exchange savings. However, edible oil, which is a main product, is imported. Therefore, its production produces a net saving of foreign exchange. The f.o.b. price of palm oil, the principal import, multiplied by the quantity of cottonseed oil produced is an estimate of the foreign exchange released for other uses in the economy.

Since the official rate of exchange generally understates the domestic willingness to pay for foreign currencies in most of the developing countries, it becomes necessary to estimate the true aggregate consumption value, expressed in domestic currency of a unit of foreign exchange. For the purposes of this analysis, we use an estimate of the shadow exchange rate of 1.04, calculated by Khan [9] by considering both import and export elasticities. A rule-of-thumb technique for deriving this estimate is to invert the consumption – conversion factor. This procedure gives the change in aggregate consumption measured in domestic market prices, which is the UNIDO definition of the shadow exchange rate. With Weiss's estimate of the consumption – conversion factor for Pakistan [20], the shadow exchange rate turns out to be close to unity. That this should be the case is not surprising, considering the massive devaluation of the Pakistani rupee in 1972 and the fact that 1975-76 data are used in this analysis.

Skilled and unskilled labour are the two remaining components for which adjustment is required. For the economic analysis, the relevant shadow price of labour is the direct cost incurred by society due to hiring an additional labourer in the industrial sector. Khan [9], using the Little and Mirrlees formulation of the shadow-wage rate [10], estimates this to be 986 rupees per unskilled labourer per year, in 1970-71 prices. This estimate is based upon the consumption of a working week of seven days in agriculture, and the marginal productivity (and hence output forgone) in the slack season equal to half the market wages in the peak season. Projecting this estimate on the basis of the growth of agricultural wages, Khan [9] found the direct cost in 1975 to be 1098 rupees. The wage-conversion factor, k = shadow-wage rate/money wage rate [10], can thus be calculated, using the annual money-wage series generated by Guisinger [6]. The value of k is equal to 0.22 (1098/4953) for 1975-76.

The shadow wage estimated using the Little and Mirrlees formula [12] is measured in uncommitted social income in terms of consumption. This formula for the shadow wage can be converted into consumption units by multiplying it by the value of savings or investment in consumption units, denoted by s [10]. Thus, to be consistent with the numeraire of the UNIDO methodology, the wage-conversion factor of 0.22 was multiplied by 1.5, the value calculated by Weiss [20], to obtain 0.33 as the wage-conversion factor for the economic analysis.

For the social analysis, the wage-conversion factor used is 0.80. The shadow-wage rate for the social analysis is greater than that used for the economic analysis because the parameters defining the shadow-wage rate suggest that the distributional impact of extra consumption generated by hiring an additional labourer is offset by the diversion of resources to consumption, and away from investment, in a capital-scarce economy.

The market price of skilled labour is regarded as an accurate reflection of its scarcity value, which is apparent from the current shortage of skilled personnel due to the migration of skilled labour from Pakistan to Middle East.

After making due adjustment for the price of foreign exchange and unskilled labour, the cash flows are discounted at 8 percent for the economic analysis and 6 percent for the social analysis. The 8-percent discount rate used in the economic analysis is taken from Khan [9] who estimates the social discount rate, taking into account both the social marginal productivity of capital and the social marginal cost of capital. The 6-percent discount rate used in the social analysis results from adjusting the 8-percent discount rate for redistributive and growth effects, as suggested by Weiss [20].

The net present values obtained from discounting the economic and social cash flows are presented in Table 4. It is clear that high-pressure expellers are the most economically and socially desirable technique for Pakistan. None of the other techniques is viable.

Table 4

Economic and Social Returns for Different Techniques

Technique	Economic Cash Flow		Social Cash Flow	
	Total Net Benefit	Net Present Value[1]	Total Net Benefit	Net Present Value[2]
Low-pressure Expeller	12,967	–18,494	1,175	–21,242
High-pressure Expeller	284,370	45,197	241,030	56,004
Direct Solvent Extractor	20,613	–87,348	–21,893	–97,848
Pre-press Solvent Extractor	19,475	–94,948	–27,448	–107,170

Source: Based on data adjusted from [4, Tables A.1 – A.4].

[1]The net present values were obtained by discounting at 8 percent.

[2]The net present values were obtained by discounting at 6 percent.

For a capital-scarce country like Pakistan, the 8-percent discount rate used in our analysis may be on the low side. Weiss [20], relying only on getting an estimate of the social marginal productivity of capital, obtains a range of 15–20 percent for the social rate of discount. However, in our analyses, the results were not sensitive to a range of discount rates tried.

In [4], the prices of cake and oil for high- and low-pressure expellers are the same. However, in practice, the outputs of low-pressure expellers fetch a premium price in the market. It is reasonable to expect the cottonseed oil price to be the same for all techniques, if we assume that the entire oil output from this sector is destined for the hydrogenated vegetable-oil (ghee) industry. All the cottonseed oil in Pakistan is utilized as input of the vegetable ghee industry, where it is hydrogenated to resemble butter fat (ghee). This process can utilize any type of oil, such as palm oil, coconut oil, sunflower oil, safflower oil, etc., and convert it to resemble the traditionally acceptable animal ghee. The taste of the oils is neutralized in the process. As such, it is possible to use the oil from high-pressure expellers without offending the taste of the consumers. It is precisely this reason that makes the cultivation of other types of oilseed, such as sunflowers etc. uneconomical in Pakistan. Because the accepted cooking medium is vegetable ghee, and this product can be made from any number of edible oils irrespective of their nutritive value, the superior oils have to compete with those of lower cost, such as palm oil. However, the problem with the by-product is different. Pakistan does not have an animal feed industry of note. Animals are reared by traditional methods. There is, therefore, a strong traditional preference for the oil-rich cake from low-pressure expellers. As compared with the cake from low-pressure expellers, the cake from high-pressure expellers, mainly because it contains less oil and is 'burnt', is thought to be inferior as a cattle feed. It, therefore, generally commands a lower price in the market than the cake from low-pressure expellers. If we reduce the price of the cake from high-pressure expellers by ten percent, we find that high-pressure expellers are also not feasible in economic or social terms. The appropriately discounted net present values, not reported here, are negative. It is clear, therefore, that none of the techniques would be economically or socially feasible if an alternative set of prices was used.

The prices of cottonseed oil and cake used in the analysis are, therefore, crucial in determining the feasibility of the techniques. It is our contention that 165 rupees per maund of edible oil is a more realistic price, because this is what the oil would cost if it had been imported. From the point of view of the economy as a whole, therefore, there is a net loss in paying the higher oil price of 200 rupees per maund. The price used for the solvent-extracted meal in the analyses is high. This would tend to bias the analysis in favour of the solvent-extraction processes. Additionally, using the same price for the cake from both low-pressure and high-pressure expellers is unreasonable, unless it is assumed that the cake from the high-pressure expellers is then solvent-extracted.

It is emphasized that the comparison here is between techniques that represent a scale of operation that is not usual in Pakistan. In comparison with the established techniques, the capital outlays involved are sizeable and the labour requirements are minimal. However, within the matrix of the prices used by Experience Incorporated [4], we find that the more labour-intensive technique of high-pressure expelling is the most optimal one. Although this is in direct contrast with the recommendations of Experience Incorporated [4], it highlights the absence of a trade-off between efficiency and employment.

CONCLUSIONS

This paper considers the choice-of-technique problem, using a case-study approach for the cottonseed oil extraction industry in Pakistan. The feasibility study, conducted by an American firm of consultants, Experience Incorporated, made the following recommendation:

> Experience Incorporated recommends that four 500 ton direct-solvent extraction plants, with seed houses, be built to supplement existing solvent-extraction capacity. Additional direct-solvent extraction plants should be built as the oilseed industries expand [4].

However, the scale of the techniques evaluated by the consultants is extremely large relative to Pakistani standards. The recommendation would involve a severe labour displacement. Additionally, if Pakistan did adopt the recommendation of setting up four direct-solvent plants, the operation of such plants at the level considered by the consultants would require more than 57 percent of the total production of cottonseed in the country. The suggestion that the solvent-extraction plants are feasible because they can be adapted for use in processing rapeseed cake and rice bran is not supported by any empirical analyses by the consultants.

The capital requirements of four such plants is greater than the total value of capital equipment in the cottonseed-oil industry in 1975-76. Pakistan would be faced with the problem of a huge capital outlay, requiring a significant amount of foreign exchange, to obtain such highly capital-intensive technology.

There is no economic justification for the recommendation of establishing the direct-solvent extraction plants for cottonseed oil processing. The high-pressure expellers dominate the solvent-extraction techniques at the prices considered. In fact, if a more reasonable price for cottonseed oil is assumed, none of the solvent-extraction techniques is feasible.

The foregoing analyses highlight some of the complex factors associated with a choice-of-technique analysis. Although the analysis is at a fairly disaggregated level, it combines a number of sub-processes such as cleaning, delinting, storage, decortication, expelling and extraction. Each of these sub-processes lends itself to a complete choice-of-techniques analysis.

The above analyses highlight an interesting aspect of the choice-of-techniques problem facing the developing countries. Governments in these countries are often bound by aid commitments and other donor-country pressures to act upon feasibility studies like the one analysed, which recommend more capital-intensive options (in this case direct-solvent extraction) than are financially, economically or socially desirable.

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Comments on "Choice of Techniques: A Case Study of the Cottonseed Oil-extraction Industry in Pakistan"

Dr Malik has presented a stimulating paper on a very timely topic. The application of technical choice analysis to the cottonseed-oil-extraction industry is particularly welcome, given the country's growing dependence on imported oil and the government's renewed efforts to strengthen the domestic edible oil industry. His analysis of an often-cited cottonseed oil-extraction feasibility study demonstrates some of the important pitfalls which one is liable to come across in choosing appropriate technologies for an infant industry.

I will direct my comments towards three special concerns raised by the paper: (1) the evaluation of the claim that choice of technique is eliminated once choice of product is made; (2) some market development assumptions that weaken the original feasibility analysis, and (3) the labour-displacement effects of technical choice.

DOES CHOICE OF PRODUCT PREDETERMINE CHOICE OF TECHNIQUE?

One of the paper's objectives was to address this question. Part of the difficulty with this issue is caused by the fact that the recommendations of the consultants' report were not adopted. We only have Dr Malik's conclusion that those recommendations were not justified because the government's decision not to implement solvent extraction technologies was probably made by default.

The paper's title raised expectations that the theoretical basis of the technology-switching controversy would be summarized and linked to Pakistan's cottonseed oil-extraction industry. Unfortunately, because this discussion was not included in the paper, some of the more fruitful results of the analysis are less useful than would be the case if the technology-switching theory had been developed.

MARKET DEVELOPMENT ASSUMPTIONS

When the feasibility study was done a decade ago, Pakistan had a small edible oil industry, with imported oils comprising a rapidly rising share of consumption.

We now enjoy the benefit of a retrospective knowledge not available when the feasibility study was finished in 1976. During the last decade the rates of edible oil consumption and imports grew far more rapidly than was predicted by any systematic forecast done during the 1970s. During the 1971–83 period, edible oil consumption increased at an annual compound growth rate of about 10 percent, but domestic oil production stagnated, particularly after 1977. From this viewpoint, the feasibility study's product price assumptions raise special concern.

Constant Oil Product Price

Firstly, the consultants assumed a constant cottonseed oil price of Rs 200 per maund. It is difficult to imagine that this assumption would stand for a twenty-year cash flow in a financial analysis. However, the consultants would also have been shocked in 1976 if they had then learned that the government would hold the price at 200 rupees per maund from 1974 until 1980, when it was raised to 250 rupees per maund! If the consultants had reviewed world edible oil nominal prices during the past one or two decades, their analysis would have revealed consistent evidence of annual growth rates of at least five percent. If the domestic oil procurement price had followed the trend of imported oil prices during the 1971–82 period, the current opportunity cost for cottonseed oil would be about 350 rupees per maund.

Constant Meal Product Price

Secondly, the feasibility study's cottonseed meal price was assumed to be 25 rupees per maund over the twenty-year life of the project. This price would have certainly cleared the market in 1976, and would have been below its marginal value product throughout the next decade, even if the poultry industry had not grown and stimulated oilseed meal demand. Today, the salvage price of cottonseed meal is at least 75 rupees per maund, even though the retail edible oil price is largely fixed.

These relatively low product price assumptions and the small improvements in extraction efficiency due to solvent-extraction technologies seem to be the major obstacles to choosing solvent techniques. The assumed oil-extraction rates varied from about 18 percent for low-pressure (Lahore) expellers to about 21 percent for both solvent-extraction processes. In the early 1970s, before solvent-extraction processing virtually disappeared, the industry's extraction rate had been estimated at about 13 percent. So, it is not surprising that Dr Malik finds the solvent-extraction technologies to be economically unsound.

It should be noted that the "science" of technology choice still involves considerable 'art". At the time of the feasibility study, the government was calling for revitalization of the domestic edible oil industry to meet growing consumer demand and substitute domestic oilseed crops for imported oil. This environment may have inspired the consultants to be optimistic about future market developments. Unfortunately, the industry stagnated during the following decade because the government was unable to decontrol retail prices and allow oilseed prices to rise in response to rising imported and retail oil prices.

The problem of choosing the appropriate size of plant is especially difficult when dealing with an infant industry, because future market developments are quite uncertain. When the Pak-China fertilizer plant was constructed, its 96,000 ton urea capacity was possibly viewed at the time as a product choice since the future demand for nitrogen fertilizer was clouded by uncertainties about wheat pricing policies and diffusion of fertilizer technologies to farmers. Today, however, Pak-China stands out in the fertilizer industry as a low-volume, high-cost plant. Ironically, to exploit prevailing economies of size, it would cost less to build a new half-million ton plant than to expand the size of Pak-China on site.

Labour-displacement Effect of Technology

Dr Malik points out the concerns about labour being displaced by new technologies. It would be useful to know how total employment would change if the adoption of the new technology led to greater output. Toward the end of the paper, Dr Malik mentions that linear programming (LP) models were used to reaffirm his earlier analytical results favouring high-pressure expellers. The specific LP analyses may have wisely been omitted from the paper for the sake of brevity, but such results often provide important insights into the labour aspects of technology choice. Extension of this analysis is contemplated and the LP approach should certainly be given greater emphasis.

The labour-displacement issue also needs far greater emphasis in this type of study because of the increasing divergence between the well-intentioned policies of governments and the reallocation of labour and capital in international markets. It is correct for governments to be concerned about labour being displaced by technology, but labour-biased technology choices will not give a nation much comfort if, relative to the international market, local labour does not have a comparative advantage. In the case of textiles, there is a growing evidence that labour can be an inferior factor of production, resulting in decreasing optimum levels of labour use, even as wage rates fall. This issue is well worth studying in Pakistan's edible oil industry.

CONCLUDING REMARKS

Dr Malik notes that the feasibility study recommended adoption of solvent-extraction technology, whereas his analysis suggests choosing high-pressure expellers. It is useful to see how the methodologies of Dr Malik and the consultants differed so as to merit recommendations for different extraction technologies, based on the same data!

Finally, there are important technology-choice problems in the agro-industrial complex that could benefit from Dr Malik's research . The textile industry must adopt new spinning and weaving technologies if it is to remain competitive in the world market. The analytical methods employed in this paper would be most useful in helping to assess the trade-offs that many textile-exporting countries seem to believe will justify more capital-intensive techniques.

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