SOUTHERN AFRICA:
FOOD SECURITY
· POLICY OPTIONS

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THE ECONOMICS OF EXPANDING COMMERCIAL WHEAT PRODUCTION IN ZIMBABWE

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INTRODUCTION

Zimbabwe produces 150,000-240,000 mt of wheat annually, depending on the rainy season (Pilditch, 1987). In contrast, the annual demand for wheat based products is presently estimated between 300,000-360,000 mt. Thus, the country has an annual shortfall of at least 100,000 mt which has to be imported. In recent years, wheat imports have taken the form of aid-assisted triangular transactions in which the country's surplus maize is exchanged for wheat. The barter trades have masked the fact that Zimbabwe would have had to pay US$10 million annually for wheat, if it had been imported commercially (based on an export price of US$100/mt). For the whole SADCC region, the commercial value of wheat imports is estimated at US$70 million annually.

Since all of the SADCC countries are experiencing the same trend of rising wheat consumption and imports, the problem of increasing wheat production extends beyond local interest when the regional dimension is considered (Thompson, 1986). In order to become self-sufficient in wheat, SADCC countries would have to invest in their domestic wheat production sectors considerably more than the value of annual imports. The form of this investment is very much tied to the respective country's agrarian structure. In the case of Zimbabwe, most investment in wheat production has been made in the large-scale commercial farming sector.

This paper analyses data collected during a 1986 survey of 41 commercial wheat farmers in examining some of the issues associated with the policy objective of increasing wheat production (Longmire, Ngobese and Tembo, 1986).

EVOLUTION OF THE WHEAT INDUSTRY

Wheat production in Zimbabwe has been closely associated with the development of the wheat-processing industry. For example, the introduction of the

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first dough mixer at a local bakery in 1927 was followed by government measures to encourage bakers to use local wheat. In 1928, a rebate on customs duties on imported wheat was introduced. Millers were eligible to receive the rebate if they blended imported wheat with at least 20% locally grown wheat. Persistent calls by the domestic processing industry for improved quality in the local crop pressured the government to direct resources toward the wheat sector. Partly in response to this pressure, the Department of Agriculture initiated a local wheat-breeding programme in 1931 (Weinmann, 1975).

Production of wheat slowly expanded with the areas planted to wheat increasing from 1,832 ha in 1925 to 8,332 ha in 1935. But the Natural Resources Board's insistence on banning riverine wetland *(dambo/vlei)* cultivation of wheat--at that time the conventional cultivation environment--subsequently led to a decline in the area grown in the post-war period.

The expansion of wheat production as a large-scale commercial sector crop was facilitated by both the development of irrigation following completion of the Kyle Dam in 1961, together with the introduction of sprinkler irrigation technology. The imposition of sanctions in 1965, curtailing commercial grain imports, gave impetus to the government's policy of assuring self-sufficiency in basic food grains production. This served to reinforce the trend towards large-scale irrigation development, particularly for wheat, since virtually all wheat had previously been imported. The liberal capital development subsidies provided by the Farm Irrigation Fund made it possible for the country to move from a wheat deficit situation before the *Unilateral Declaration of Independence* (UDI) to an actual surplus during 1976-78. However, since 1980 the demand for wheat has once again outstripped the supply.

WHEAT PRODUCTION STRUCTURE AND RESOURCE USE

Table 1 shows the distribution of farms in Zimbabwe; classified according to the area under wheat, the proportion of the total wheat area, and the proportion of total production contributed by each size class.

Seventy percent of Zimbabwean wheat operations have less than 100 ha planted to wheat. However, this group of small operations represents only 32% of the total area planted to wheat and accounts for only 30% of the total quantity produced. In contrast, the remaining 30% of large operations, with an area planted to wheat above 100 ha, accounts for 68% of the total wheat area and 70% of total production.

Differential access to resources--particularly water and capital--appears to influence the size of wheat operations and may account for the size

Table 1. Size distribution and output of wheat operations in Zimbabwe, 1987.

Wheat area of farms (ha)	Total no. area (%)	Total wheat production (%)	Total wheat (%)
1 - 20	14	3	2
21 - 100	56	29	29
101 - 200	20	29	30
> 201	10	39	40

Source: CSO (1987).

heterogeneity shown in Table 1. For example, the nature of the water source (e.g., flow right to a "public" river, private farm dam, borehole) affects how much wheat can be irrigated. Approximately 40% of the wheat farmers surveyed in 1986 (Longmire, Ngobese and Tembo, 1986) cited private farm dams as their major water source. Only 23% possessed a flow right to a "public" river, and 18% obtained water from government dams. The rest owned boreholes or shared a private dam with other farmers. On average, farmers with their own private water supply planted a larger area to wheat. Although privately-owned water is generally more expensive than "public" water, the greater availability and reliability of private water enables farmers possessing their own water source to plant greater areas.

Restricted access to capital also appears to influence the size of wheat operations. In comparison with other commercial crops grown in Zimbabwe, wheat is relatively capital intensive in that it requires full irrigation and a high degree of mechanization (e.g., combine harvesting). Expansion of wheat area consequently requires considerable capital investment as well as access to imported machinery, both of which presently pose problems. Most wheat farmers reported that the modest profitability of wheat does not justify investment in irrigation, unless wheat is grown in rotation with other high value crops. Furthermore, the availability of agricultural machinery needed to grow wheat has been severely restricted by the current foreign exchange shortage, indicated by the fact that the average age of combine harvesters owned by the survey respondents was eight years.

PROFITABILITY OF WHEAT PRODUCTION
BY SIZE OF OPERATION

Data generated by the 1986 survey of commercial wheat farmers were used to construct enterprise budgets, based on 1985 prices (Ngobese, 1987). Given the size heterogeneity of wheat operations, particular attention was directed to the question of whether wheat production is most profitable at a particular size of operation. Therefore, the survey respondents were grouped into 10 size classes, with the objective of calculating the optimal size of a wheat operation. Representative budgets were constructed for each size class. Table 2 summarizes the variation in net returns, by size of operation. (See Ngobese, 1987 for the complete set of budgets).

Table 2. Net returns by size of wheat operation, 1986, Zimbabwe.

Size of operation	Average: total costs	net returns	Break-even yields	Average net returns to: Water	Labour	Working capital
(ha)	(Z$)	(Z$)	(t/ha)	(Z$/mm)	(Z$/hr)	(Z$)
Highveld						
20 - 40	1,227	232	4.3	2.17	1.53	4.53
41 - 79	1,333	525	4.7	3.46	3.59	7.04
80 - 100	1,261	460	4.4	3.34	5.00	7.94
101 - 139	1,185	519	4.2	4.46	3.32	9.25
140 - 160	1,146	562	4.0	4.61	4.28	10.04
161 - 199	1,191	668	4.2	4.26	5.35	11.39
847[a]	1,021	489	3.6	3.75	3.41	9.81
Lowveld[b]						
200	808	189	2.8	2.04	2.75	5.37
440	974	288	3.3	2.54	5.22	6.63
1975	977	(7.67)	3.4	0.95	0.94	0.86

[a]A single corporate farm
[b]single farms
Source: Wheat farm survey

It is difficult to directly compare highveld and lowveld wheat operations since climatic conditions, input use levels, and yields differ considerably. These differences are reflected in the fact that production costs are generally lower in the lowveld. However, it is interesting to note that the pattern of average total costs behaves differently as the size of the wheat operations increases. On the highveld, total costs per hectare decline with size of operation over the entire range of farm sizes surveyed. In contrast, in the lowveld total cost per hectare increase with size of operation over the limited range of farm sizes surveyed. This is reflected in the downward trend in the break-even yield as wheat area increases on the highveld. In contrast, in the lowveld, the trend is upwards. (The break-even yield is the yield at which gross revenue just covers total costs).

While policy makers may be most interested in producing wheat at minimum cost, farmers are more concerned with profitability, as measured by net returns per hectare. Table 2 indicates that on the highveld, net returns per hectare increase with increasing size of operation up to the 180 ha operation, beyond which they decrease. On the lowveld, net returns per hectare increase with increasing size of operation up to the 440 ha operation, beyond which they decrease as well.

Conventional profitability analysis, which measures net returns per unit area, implicitly assumes that land is the limiting factor of production. In cases where other factors are limiting, it is instructive to examine the net returns to other factors of production. As part of the profitability analysis of different sizes of wheat operations, net returns were also calculated to water, labour, and capital (Table 2).

On the highveld:

o Net returns to water increase with increasing size of operation, up to the 150 ha operations, and decrease thereafter.
o Net returns to labour show no consistent pattern.
o Net returns to working capital increase with increasing size of operation, up to the 180 ha operations and decrease thereafter.

On the lowveld:

o Net returns to water increase with increasing size of operation, up to the 440 ha operation, and decrease thereafter.
o Net returns to labour increase with increasing size of operation, up to the 440 ha operation, and decrease thereafter.
o Net returns to working capital increase with increasing size of operation, up to the 440 ha operation, and decrease thereafter.

The observed decreasing average costs of production and increasing net returns as the size of wheat operation increase suggest there are economies of size in wheat production in Zimbabwe. Thus, the analysis suggests that wheat production is a viable enterprise for larger operators, as they are able

to spread their fixed costs (e.g., machinery, irrigation) over a large production base. Furthermore, the data suggest that the profitability of wheat farming is optimised at a farm size larger than most farms in Zimbabwe.

REGRESSION ANALYSIS TO DETERMINE OPTIMAL SIZE

Analysis of the optimal enterprise size was further explored through regression analysis. Because the survey sample included only three wheat farms located in the lowveld, subsequent statistical analysis was restricted to the 38 wheat farms located on the highveld. Ordinary least square estimation of a quadratic response function relating net revenues to size of highveld wheat operations gives the following results:

Model 1: Net returns per hectare
    NR   = 232.43 + 2.89 AWT - 0.003 AWTSQ
            (2.86)* (3.52)* (-3.47)*
    Adjusted R^2 = 0.63. F = 6.18

    where:
    NR   = net returns per hectare
    AWT   = wheat area
    AWTSQ   = what area squared

    t-statistics given in brackets under parameter estimates
    * significant at the .05% level.

The wheat area which maximizes net returns (per unit area) is calculated by differentiating the net revenue regression equation with respect to the area of wheat; and setting the first derivative equal to zero. Using this approach, the wheat area which maximizes net revenues on highveld farms equals 481.66 ha.

Optimality, defined in terms of maximizing net returns, represent the farmer's point of view; since it is generally assumed that profit maximization is a primary goal of farmers. An alternative way to consider optimal size is in terms of the country's point of view (i.e., in terms of minimizing wheat production costs). Ordinary least square estimation of a quadratic response function relating average total costs to size of highveld wheat operations gives the following results:

Model 2: Average total costs of production

ATC $\quad$ = 41.52 - 0.269 AWT + 0.0003 AWTSQ

$\quad\quad\quad\quad$ (7.11)* (-4.55)* (4.13)*

Adjusted R^2 = 0.81, F = 13.91

where:

ATC $\quad$ = average total costs of production per hectare

AWT $\quad$ = wheat area

AWTSQ $\quad$ = what area squared

t-statistics given in brackets under parameter estimates

* significant at the .05% level.

The wheat area which minimizes average total costs (per unit area) is calculated by differentiating the average total cost regression equation with respect to the area of wheat, and setting the first derivative equal to zero. Using this approach, the wheat area which minimizes average total costs of production on highveld farms equals 448.3 ha.

These regression results suggest that there is little difference in the optimum size of operation, considered from the farmer or the national point of view. Because the survey sample included only a limited number of wheat operations in the larger size categories (>200 ha), reflecting the actual composition of the population, it is unwise to place too much confidence in the specific figures generated by the optimization calculations. However, the analysis suggests that the size of wheat operation which maximizes net returns and average total costs of production is considerably larger than most wheat operations in Zimbabwe.

CONSTRAINTS TO INCREASED PRODUCTION

Zimbabwe will face several difficulties in attempting to increase wheat production.

Difficulty of achieving optimum size

The data presented above suggest that economies of size in wheat production are not being fully exploited in Zimbabwe.

Irrigation constraints--for example, the limited availability of water and the high capital costs of developing an irrigation scheme--are major factors why the size of most wheat operations is suboptimal. Another factor explaining the suboptimal size of wheat operations is that the choice of summer crops largely (and by implication, the crop rotations) determines the area grown to wheat. Summer crops such as maize, tobacco, cotton, soya-

beans, and groundnuts are often the main cropping enterprise, with wheat of secondary importance. Consequently, the area planted to wheat is determined residually, after the farmer has committed himself to his summer crop(s).

Cost of irrigation

The budgets indicate that irrigation costs (water storage, irrigation equipment, and pumping costs) are the most expensive production inputs. A sprinkler irrigation scheme costs on average Z$3,000/ha, with an additional Z$3,000/ha required for water storage. It is apparent that farmers are not willing to pay the full private costs of this development, at least not for wheat production alone. A substantial proportion of this cost may have to be borne by public expenditure, as evidenced in the subsidy provided by the National Irrigation Fund (NIF) and state farm operations set up under the Public Sector Investment Programme. For example, the NIF provides loans for private irrigation development at a subsidized interest rate of 9.75%, as compared to the Agricultural Finance Corporation loan rate of 13.9% and a commercial bank rate of 16-18%. The NIF loans are conditional on the recipients growing a certain hectarage of wheat. Up to 6,000 ha of wheat have been brought into production since 1984 when the fund was established.

Despite the high cost of irrigation, there are opportunities to achieve savings on irrigation costs through improvements in application efficiency (Longmire, Ngobese and Tembo, 1986; Tembo and Sezanje, 1987). Yet, because increasing irrigation efficiency is expensive, farmers apply excess water rather than make the additional investments to increase efficiency, especially if they continue to earn profits (LeBaron and Keller, 1986). Since maximizing yields does not necessarily mean maximizing profits, wheat farmers may be able to increase profits by planting a larger area and settling for lower yields (Longmire, Ngobese and Tembo, 1986),

Farmers are generally less efficient in their irrigation scheduling in water surplus situations. But in situations where there are water shortages, farmers are automatically forced to try to make efficient water-use decisions (LeBaron and Keller, 1986). Typically, they vary the area planted to wheat in order to optimise the value of water. This means deciding how much land to leave unplanted in order to concentrate expected water supplies on the remaining land. While wheat production inevitably will decrease in times of drought, the increased attention paid by farmers to water allocation may mitigate the production decrease.

Lack of material for summer wheat production

One major constraint to expanding wheat production in Zimbabwe is the lack of materials suited to the summer growing season. The future success of rainfed summer wheat production will depend on the outcome of ongoing breeding programmes which are seeking to develop disease and drought tolerant cultivars. Hypothetical budgets suggest that while yields as low as 2 mt/ha may enable farmers to cover variable costs of production, yield of at least 3 mt/ha are needed to make summer wheat competitive with other summer crops (Morris, 1987).

CONCLUSIONS

Zimbabwe has achieved significant progress over the past 20 years in increasing its level of wheat self-sufficiency. The marked increase in wheat production has been made possible by an incentive producer price, extensive investment in irrigation, and the adoption of high-yielding wheat varieties. Nevertheless, the fact that in recent years wheat consumption has increased more rapidly than production, underlines the need to expand wheat production at an even faster rate in the future.

This paper has examined the economics of wheat production on commercial wheat farms, with the goal of identifying constraints to expanding production in the future. Regression analysis of enterprise budget data revealed that most commercial wheat operations are of suboptimal size, in the sense that net returns to wheat production could be increased (and average total costs lowered) if cultivated area perform was increased. This suggests that the efficiency of wheat production could be increased by increasing area planted to wheat on each farm. Since area planted to wheat typically represents only a portion of total farm size, this would seem feasible in Zimbabwe. Furthermore, any future structural change that results in a decrease in the average size of wheat operations might conflict with production efficiency and lower the profitability of wheat. This seems to have happened in Kenya. Where wheat-producing land has been parcelled out to smallholder farmers, there has been a shift out of wheat production into maize production.

The lack of suitable material for summer wheat production (and the disease problems associated with summer wheats) implies that future production increases will probably have to come from an increase in irrigated area. Based on current demand levels, the cost of self-sufficiency in wheat for Zimbabwe will include the cost of bringing under irrigation an additional 24,000 ha (assuming no change in yields), representing an additional investment of Z$144 million at current prices. This means new irrigation investment will have to be undertaken at a rate of 3,000 ha per year. At this

annual rate of expansion, by the year 2000, the total irrigated area of wheat would be 72,000 ha. At an average yield of 6 mt/ha, Zimbabwe could produce 432,000 mt of wheat, just short of the project demand of 600,000 mt.

Increasing irrigated area at an annual rate of 3,000 ha obviously will be extremely costly. The relatively modest profitability of wheat suggests that farmers are unlikely to bear the full cost of irrigation investment for wheat alone, unless producer prices are raised to unsustainably high levels. But returns to irrigation investment could be increased in at least two ways. First, considerable scope exists for increasing the efficiency of water application. Second, farmers can more fully exploit their irrigation systems through innovative management practices aimed at maximizing returns across the entire crop rotation (e.g., by taking advantage of complementarities between crops). Plant breeders also have an important role to play in this respect. For example, by developing varieties that can be harvested early or planted late, they can reduce the conflict with other crops in the rotation.

Domestic wheat production in a tropical environment is generally a high cost option (Andrea and Beckman, 1985), although experience elsewhere in Africa indicates that wheat can be profitable when grown as a second, or even a third crop in a multiple crop rotation. Domestic resource cost analysis suggests that this is the case for Zimbabwe, since the cost of irrigation investment can be spread across several summer crops (Morris, 1987). Thus, despite obvious constraints to expanding wheat production in Zimbabwe, there is reason to be optimistic that wheat will continue to have a place in the farm enterprise.

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