AN ECONOMIC ANALYSIS OF FACTORS AFFECTING WHEAT PRODUCTION IN ZAMBIA

By

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Dedication

To my dad, Mr. Gideon Hichikumba, who, despite his desire to see me attain higher levels of education, God's call could not let him see me beyond high-school.

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Abstract

This study investigated the impact of rising production costs on wheat production in Zambia. Since the study, among others, aimed at coming up with policy recommendations to boost wheat output, emphasis was placed on the behaviour of wheat farmers viz-á-viz changes in the production costs.

To achieve the study objectives, a translog cost-function was specified and, from it, factor demands and estimated factor shares were derived. Because of data limitations, only land was included in the model as a quasi-fixed input. Other fixed inputs like machinery, buildings, etc. were not.

With the assumption of profit maximization invoked, and given a translog cost-function, an output-supply equation was derived and tested as to whether that equation should be included in the share equations. The test was rejected at 5 percent significance level. An alternative output-supply equation was thus specified and estimated to determine the impact of wheat product price and variable factor prices on wheat output.

The properties of linear homogeneity and cross-price restrictions of the cost-function were both not rejected at 5 percent significance level. Though negative semi-definiteness of the Hessian matrix was not tested, the results tend to suggest that wheat producer behaviour is consistent with cost minimization. With the exception of fuel for farm machinery, the results showed that, at the very least, farmers do not reduce factor usage despite increases in variable factor prices. Also, results from the output-supply equation showed that there is a lagged effect of wheat price on output-supply. Neither was output adversely affected by increases in production costs. Increases in the output price

seems to have been sufficiently high to off-set the impact of rising variable factor prices on wheat output. While wheat price had a statistically significant influence on output, the factor prices, either individually or jointly did not.

Although wheat price had a significant and positive influence on output, output-supply was not responsive to product price changes but to changes in hectarage. The price elasticity of supply was 0.084 while the hectarage elasticity was 1.03 .

In terms of policy formulation, the conclusions drawn from the results suggest that government need not provide subsidies on variable inputs as long as wheat price is sufficiently high. However, government policy should facilitate entry into the industry.

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CHAPTER 1

INTRODUCTION

1.1 General Overview

This study investigates the impact of rising costs of production on wheat output in Zambia. It is expected that the study will provide important insights into policy formulation and implementation if Zambia is to attain the goal of self-sufficiency in wheat products.

Although wheat products do not constitute staple foods for the vast majority of Zambia's 8.02 million people, they nonetheless constitute a significant proportion in the diets of most people, especially urban consumers. The fast food industry—selling hamburgers, hot-dogs, etc.—is rapidly expanding as most employees in the urban setting find it more convenient to consume fast foods during working hours than to consume traditional food-stuffs. In terms of agricultural activity, wheat is emerging as one of the dominant crops among the large scale commercial farmers.

The Government's objective for the wheat sub-sector calls for self-sufficiency in wheat to save the nation much needed foreign exchange from wheat imports. To this end, various policies aimed at facilitating the increase in its production have been adopted.

In recent years, production costs, not only in the wheat sub-sector but in the agricultural sector as a whole have been rising. Prices for all production inputs have risen drastically. For instance, the real price of ammonium nitrate fertilizer rose from ZK75.00 in 1986 to ZK257.56 per tonne in 1991.

The rise in the cost of production is a direct reflection of the high inflation rate in the economy. The inflation rate rose from 54.5 percent per annum in 1986 to 93.8 percent in 1991[1]. Interest rate on borrowed money has also been rising. For instance, in 1985, the annual rate on agricultural loans was 23.5 percent. It rose to 33 percent per annum by 1989; 43 percent by 1990; and by the end of 1991, it had risen to 53 percent per annum.[2]

Another factor affecting the costs of production is the exchange rate between the Zambian currency, the kwacha (ZK), and the U.S. dollar viz-á-viz other hard currencies. Between 1964 and 1982, the exchange rate fluctuated between ZK0.6434 to U.S.$1.00 and ZK0.9304 to U.S.$1.00. In 1983, the kwacha was devalued such that ZK1.25 was equivalent to U.S.$1.00, and by October 1985, U.S.$1.00 was equivalent to ZK2.25. Due to persistent shortages of foreign exchange, a system of auctioning foreign exchange was introduced in October 1985. This caused an acceleration in the depreciation of the kwacha. Within 18 months of auctioning, the kwacha depreciated to ZK21.00 per U.S. dollar. The auctioning of foreign exchange was then discontinued and the kwacha was revalued temporarily. Later, a series of devaluations followed. By March 1992, U.S.$1.00 was equivalent to ZK125.00.

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[1] *Source*: Central Statistical Office: Selected Indicators, 1964-1991

[2] Ibid.

1.2 Problem Statement

The factors outlined above have a direct bearing on agriculture in general and on wheat production in particular. Credit is a critical input in the Zambian farming system. A rise in the cost of borrowing money for farming purposes directly raises the cost of production. Also, a significant proportion of production inputs have an import component. About two-thirds of the fertilizers used are imported, and so are most of the chemicals. Virtually all machinery is imported. Thus, devaluation of the local currency against the U.S. dollar directly raises the cost of production as changes in the exchange rate are reflected in changes in domestic price levels of the factors of production. Therefore, as production costs change, there is need to know both the direction and the magnitude of the wheat farmers' responses to such changes. This requires analyses of producers' behaviour. Knowledge of producers' behaviour would greatly benefit the agricultural planners in developing and executing policies to raise wheat output, and hence attainment of self-sufficiency in the product.

1.3 Background on Wheat Production in Zambia

Compared to other major crops like maize, cotton, sunflowers, and tobacco, wheat production is a relatively new activity in Zambian agriculture. The crop is entirely produced by large scale commercial farmers[3]. This is due largely to the high cost of

[3] Zambian agriculture is composed of three distinguishable categories of farmers: small-scale farmers cultivate less than ten hectares of land annually. Most of what they produce is for domestic consumption with very little surplus for sale. Emergent farmers cultivate anywhere between 10 and 40 hectares of land. They use relatively improved production techniques as compared to small-scale farmers, and a significant proportion of their produce is geared for market. Large scale commercial farmers are highly mechanized. Area cultivated on individual farms ranges from 40 to several thousand hectares annually. Generally, all their produce is geared for market.

production which prohibits production of the crop by small-scale and emergent farmers (Kasalu and Johnson, 1988). Until the early 1970s, wheat production was almost non-existent. In 1976, total output was only 4,000 metric tonnes (mt)[4] nation-wide. Production rose modestly to 9,600 mt by 1980. Thereafter, a relatively sharp increase was experienced such that by 1988, production reached 32,000 mt. The increase in production continued and by 1991, reached 60,000 mt. In terms of acreage, area harvested has risen from 3,700 hectares in 1982 to 11,849 hectares in 1991. Number of growers, area planted and production levels for the period 1986-1991 are shown in appendix B.

As of 1988, annual domestic consumption of wheat was estimated at 120,000 mt. This is the figure still quoted officially despite the fact that the population has risen from 7.53 million in 1988 to 8.02 million in 1991. This is perhaps explained by the fact that government banned wheat imports with effect from 1988. This makes it difficult to determine how much wheat would be consumed if it were readily available.

Up to 1988, the deficit in wheat requirements was met by imports mainly from the United States and Canada. Between 1979 and 1984, commercial imports of wheat averaged about 96,000 mt per year (Kasalu, 1987). Figure 1 below shows wheat imports and domestic production for the period 1970-1991[5]. Note that no wheat has been imported since 1990. This is because Government was pressured by farmers to ban all wheat imports in 1988. And it seems the policy became fully effective in 1990. The ban was aimed at promoting increased domestic production of the crop as imports depressed

[4] Source: *Annual Agricultural Statistical Bulletin, 1982.*

[5] Import and production data were obtained from FAO Trade Yearbook and Agricultural Statistics Bulletins respectively.

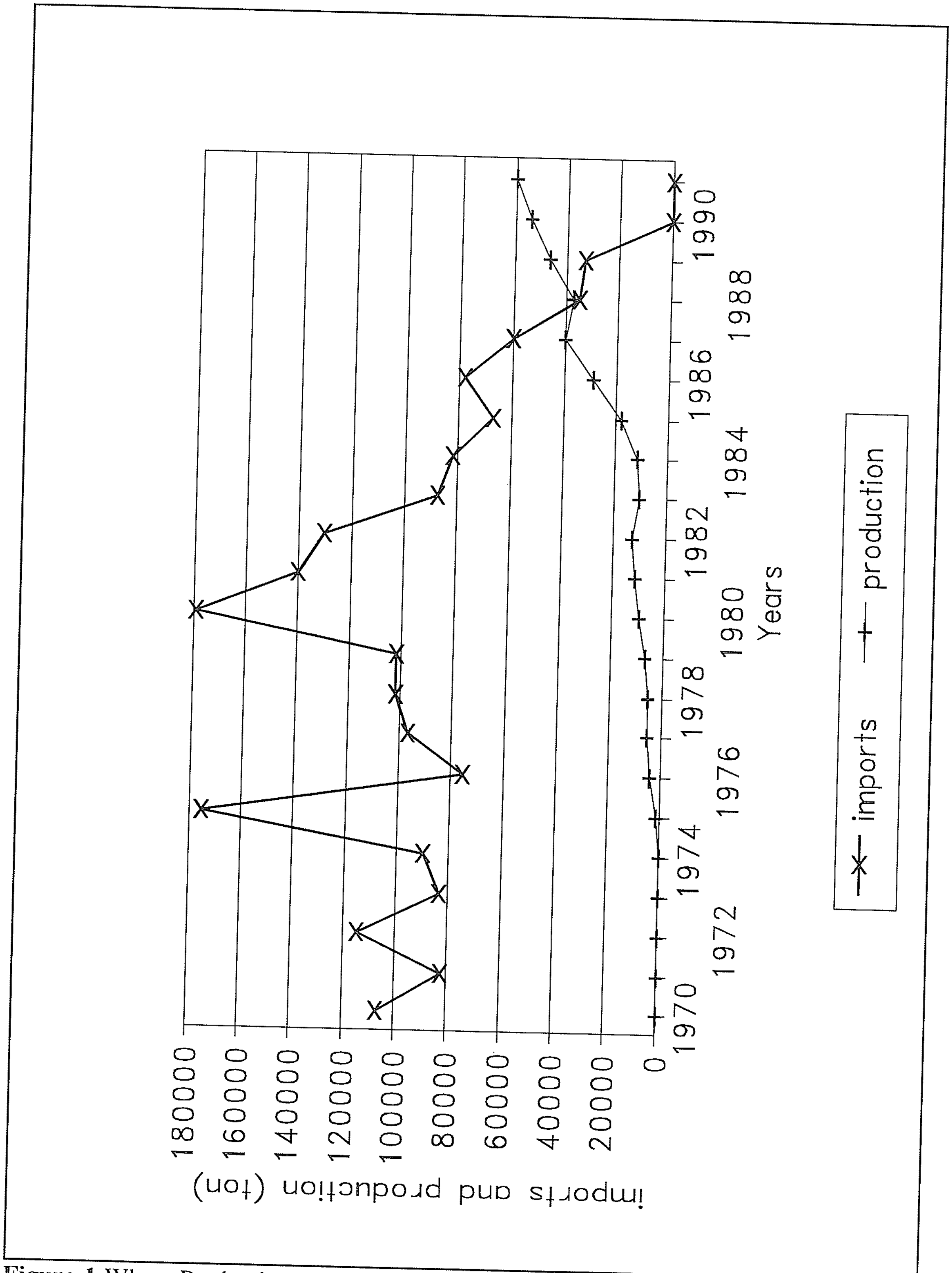

Figure 1 Wheat Production and Imports in Zambia: 1970-1991

the domestic price. Thus, in view of the wheat import restriction, there is urgent need to dramatically increase production if consumer welfare is not to be compromised.

In Zambia, wheat is grown under irrigation during the dry season—from early May to September. As an irrigated crop, wheat has a high potential in most parts of the country[6]. But presently, production is concentrated in southern and central parts of the country. This concentration is attributed to better infrastructure in these areas as compared to the rest of the country. The main rail-line, roads and the major electricity supply lines pass across this part of the country from the south to the copper mines on the Copperbelt in the north.

The Government has been undertaking measures to promote rain-fed wheat production. So far, the results suggest that producing rain-fed wheat is not economically viable. Average yields are very low. They range from 1.5 to 2.0 mt per hectare. On the other hand, average yields for the irrigated crop range from 5 to 6 mt per hectare. In fact, some farmers have reported yields as high as 9.5 mt per hectare[7].

Due to the fact that there exists no national water master plan with systematic balancing of water supplies and demands and detailed information on soils and their suitability for wheat[8], it is not possible to give an exact picture of what wheat production potential is in Zambia. However, the Ministry of Agriculture considers the production potential to be vast as already indicated. Some studies contend that Zambia has irrigation

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[6] Department of Agriculture, Commercial Crop Production Recommendations, McPhillips, J.K. (ed) (Lusaka, 1987).

[7] Ibid; also responses from the survey.

[8] World Bank, (Zambia), Agriculture Sector Strategy: Issues and Options, vol. 1, January, 1992.

potential of 12 million hectares (Lundondo, 1988). Of this, only 25,000 has been developed with 11,849 under wheat while the rest has been developed for sugar-cane production. In the same vein, Kasalu and Johnson (1988) argued that "technically there is vast production potential for wheat in Zambia. The soils and climate are generally suitable for wheat farming and the country has vast under-utilized water resources which can be used for irrigation" (Kasalu and Johnson, 1988). In fact available statistics indicate that of the country's total land area of 75 million hectares, 42.4 million is available for crop production. Currently, the cleared land area is about 14 million hectares of which only an average of 2.1 million or 5 percent is cultivated annually[9]. Water resources are abundant too. It is estimated that the country has 90 billion litres of yearly run-off of renewable water and 150 billion litres of water storage. Thus, the resource endowment required for increased wheat production exists.

The only crops that compete with wheat in terms of productive resources like land are potatoes and barley. However, they do not constitute a significant proportion of crop production in the sector. Maize does not compete with wheat as production seasons for the two crops differ. Maize is grown during the rainy season (from mid November to April) while wheat is grown during the dry season under irrigation when temperatures are less suitable for maize.

Up to 1985, the government's agricultural policies involved controlling producer prices of almost all agricultural products including wheat[10]. Wheat prices were de-

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[9] Source: *Annual Agricultural Statistical Bulletin, 1989.*

[10] Ministry of Agriculture and Water Development, (July, 1986), Fourth National Development Plan, 1987-1991:Summary Reports

controlled thereafter while the rest remained controlled until 1990. In most cases, prices were arguably not high enough to induce increased production. The rationale for controlling producer prices was to make food affordable to urban consumers—a policy whose effects may have been adverse to the agricultural sector as a whole as it did not encourage new investments in the sector. However, for wheat and soybeans, prices seemed generally sufficiently high because wheat and soybeans products were not considered to be staple foods (or necessities). Even after wheat price decontrol in 1985, Government still set floor prices so as to ensure that farmers got a reasonable price. The end result of this pricing policy was arguably that most commercial farmers shifted their production patterns from other crops to wheat and soybeans. Partly due to the realization that price controls were hurting both consumers (due to the resultant food shortages) and producers; and partly due to strong pressure from the farmers' lobby group, the Government de-controlled all agricultural producer prices in 1990. At the same time, the monopoly in the marketing of agricultural produce enjoyed by government marketing boards was dismantled so as to allow private agents to engage in the marketing of agricultural products.

1.4 Objectives and Hypotheses

1.4.1. Objectives

This study investigates the impact of rising variable costs of production on wheat output. The major objectives therefore are:

(i). To determine the impact of changes in variable production costs on wheat farmers' behaviour.

(ii). To determine the impact of variable factor prices on wheat output.

(iii). To determine farmers' response in terms of output-supply to changes in wheat price.

(iv). And lastly, to suggest policy implications of the study to boost wheat output.

1.4.2. Hypotheses

To achieve the objectives outlined above, several hypotheses regarding wheat farmers' behaviour will be tested. The hypotheses to be tested are as follows:

(i). The first hypothesis is that farmer behaviour does approximate cost minimization.

(ii). The second hypothesis is that the high inflation as well as low exchange rates, and therefore the high input prices that they entail have limited increases in wheat production. That is, we shall test whether variable factor prices individually or jointly have significant influence on wheat output.

(iii). Lastly, we shall test the hypothesis that wheat price has a significant and favourable influence on output. The result of this hypothesis test will reveal as to whether wheat price can be used as an instrument to influence output.

1.5 Scope and Organization of the Study

This study focuses on wheat production in Zambia with a view of considering policy recommendations that will facilitate the increase in its production. As has already been indicated, the government's policy objective in the wheat sub-sector is to attain self-sufficiency in wheat. To achieve this objective, the government has undertaken several measures including the ban on wheat imports. However, expansion of wheat output may not be easy because of the large and frequent increases in input prices. Thus, the need for a study that will provide insights into economics of wheat production.

To achieve the objective of the study, input demand functions, derived from a given cost function, will be estimated. For policy purposes, elasticities will be calculated from the estimated parameters. Also, to enable evaluation of the impact of the product price on wheat output, an output-supply function will be specified and estimated. Thus, the empirical model will make use of both the cost-function and output-supply approaches. In the event that these approaches fail to give results which reasonably approximate actual conditions, an accounting approach will be undertaken.

The thesis is organized into six chapters. Chapter two reviews the literature that is relevant to the study. The theoretical framework within which the investigation will be conducted is presented in chapter three. This includes the specification of the empirical model to be used in the analysis. Chapter four is a discussion of how data was collected as well as the analytical procedures. Empirical estimations of the model, analysis of the results, conclusions drawn and policy recommendations are presented in chapter five. The summary, limitations of the study and scope for further research follow in chapter six.

CHAPTER 2

REVIEW OF LITERATURE

Perhaps because it is relatively a new crop, there exists little literature on the economics of wheat production in Zambia. Most studies on Zambian agriculture have focused on maize production as if agriculture was synonymous with maize production.

Mwape (1988) completed a study whose principal objective was to determine the relative technical, price and economic efficiencies of emergent and commercial farmers. His focus was on the maize crop. To test for the relative economic efficiency of the two farmer groups, he specified and estimated a profit function, and a variable input demand function. The results showed that there was no significant difference in the economic efficiency of the two farmer groups.

Muntanga (1984) analyzed the uniform pricing system for maize by comparing it to the free market pricing system. He determined "the regional optimal flow of maize and their corresponding equilibrium price differentials so as to judge whether the uniform pricing system was efficient or not." His findings were that the uniform pricing system was highly inefficient. Some regions were not economically feasible for the massive production of the crop that existed at that time.

There are many other studies whose prime focus is maize. They have been done by both academicians and planners in the Ministry of Agriculture. The reasons for paying disproportionately more attention to maize range from arguments related to data availability to arguments like "maize is the staple food for the majority of Zambians".

Truly maize is the staple food, but its agricultural importance is diminishing both in relative and absolute terms. While its production volume has either remained constant or even fallen (due to persistent droughts) in the last decade, the production of other crops like soybeans and wheat has been on a steady increase. For instance, while wheat output increased more than five folds in a little over a decade, yearly maize production fluctuated between 720,000 mt and 1.1 million mt during the 1976-1987 period. Only in 1988 did it reach 1.9 million mt. However, in 1991, it dropped to 360,000 mt; and in 1992, due to a severe drought, it was expected to be as low as 180,000 mt or even less. In spite of this, only a few studies have attempted to focus on other crops like wheat or soybeans.

One major study on wheat is that done by Kasalu (1987). Kasalu investigated the efficiency of wheat production in Zambia using a cost-benefit analysis approach. She analyzed three model farms representing three different modes of production for the 1985 crop year. These were "estate cooperation, irrigated commercial and rain-fed commercial production categories". The model estate cooperation farm is jointly owned by the Zambian government which finances local capital as well as other inputs and foreign investors who finance foreign capital inputs. The other two categories are purely privately owned and must secure financing, local and foreign, on their own. Note that the production techniques between what Kasalu defined as estate cooperation and irrigated commercial farm are the same. They both produce wheat under irrigation. The only difference is the composition of farm ownership.

Kasalu also examined the foreign exchange costs and the economic viability of producing wheat locally as opposed to importing it. Her conclusions were that it was financially and economically feasible to grow wheat using the estate cooperation category and that it also made efficient use of Zambia's limited national resources. In comparison, the irrigated commercial category was financially profitable but not quite economically feasible, and inefficiently used the country's resources. The rain-fed category was neither financially nor economically viable at the then yield levels. She further observed that, although all three categories saved foreign exchange by producing wheat locally, only the estate cooperation category resulted in economic and financial savings over imported wheat. She recommended that government should promote estate cooperation production as opposed to irrigated wheat commercial production.

One area of difference between the current study and Kasalu's study is the analytical procedure used. Using the cost-benefit analysis approach, a project is assessed positively if the benefits exceed the costs (Stone, 1982), and conversely if the costs are greater than the benefits. But what can be problematic with this approach is a situation where during the time period in which the project is being considered, the costs exceed the benefits and the project is viewed negatively. Yet, in the long-run, the benefits would exceed the costs due to the economies of scale resulting from adoption of more efficient production technologies which shift the production function outwards. But depending on the cost-benefit ratio above or below one, such a project would be rejected because the potential for future benefits could not be foreseen at the time. As Tomek and Robinson (1990) observed, changes in aggregate farm output overtime have been associated mainly with shifts in the production function. But this phenomenon does not seem to be accommodated by this approach.

Also, using a cost-benefit analysis approach does not facilitate the analysis of decision making behaviour of producers. All this tends to lead to the conclusion that the conclusions and recommendations derived from cost-benefit analysis may be misleading as far as assessment of potential benefits of certain projects are concerned.

One study reviewed despite it being conducted in an environmental setting different from the current study is that done by Sidhu and Baanante (1981). Sidhu and Baanante's study used farm-level data to estimate input demand and wheat supply in the Indian Punjab. They used a normalized, restricted, translog profit function. The flexibility afforded by the translog profit formulation allowed the exogenous variables to produce different impacts across input demand functions. Policy-relevant elasticity estimates with respect to variable inputs and output prices, fixed inputs, and other variables usually considered constraints to farm production were obtained. They found that all fixed inputs appeared to be important in influencing wheat supply.

Sidhu and Baanante's study is similar to the current study in that the current study uses disaggregated farm-level data. The two differ in that the current study is over a four year time period. That used by the former was over a one year time period. Also, both studies obtain elasticity estimates that will enable the development of policies which could lead to a rapid increase in wheat production. Thus, the study benefitted a great deal from Sidhu and Baanante's study in terms of developing an appropriate empirical model.

CHAPTER 3

THEORETICAL FRAMEWORK AND MODEL SPECIFICATION

3.0 Background

There exists a great deal of literature in microeconomic theory which can provide a framework within which investigations of the problem for this study can be conducted. However, data availability considerations constrain the choices that are feasible.

A more traditional approach would be to specify a production function and derive factor demand and output supply responses from the first-order-conditions. But this approach has several major drawbacks. To derive factor demands and output supply responses, one has to solve complex systems of first-order-conditions. But for many functional forms, this cannot be analytically done (Lopez, 1982). The need to impose more restrictive conditions on the estimating equations is yet another unattractive feature of the production function approach. Depending on the functional form used, restrictions on the values of the elasticities of substitution etc. have to be imposed (Lopez,1982).

Some other unattractive features of the production function approach have to do with imprecise estimates if input demands are co-linear; and the difficulties in calculating partial elasticities of substitution (Pope, 1982) if one wished to determine the degree of substitution within inputs if relative factor prices change.

To a large extent, these problems have been resolved with the advent of duality theory which has become popular in microeconomic theory during the last two decades.

The dual approach, coupled with the flexibility afforded by some functional forms (Sidhu and Baanante, 1981; Pope, 1982), usually is easier to apply, likely more flexible in measurement, and able to conveniently analyze more problems while at the same time ensuring consistency with say, the hypothesis of competitive cost minimization in the case where the cost function is being used (McFadden, 1978). For instance, if one wished to determine the partial elasticity of substitution, for the primal approach, it is determined by the formula

$$\sigma_{ij}=\frac{\sum_{i=1}^{n} x_i f_{ij}}{x_i x_j} H^{-1}_{(ij)} \tag{1}$$

and for the dual approach, it is

$$\sigma_{ij}=\frac{c}{c_i c_j} c_{ij} \tag{2}$$

where $H^{-1}_{(ij)}$ is the i-j element of the inverse of the hessian of the production function {f(x)}; and

$$f_{ij}=\frac{\partial^2 f}{\partial x_i \partial x_j}, \quad c_i=\frac{\partial c}{\partial p_i}, \quad c_{ij}=\frac{\partial^2 c}{\partial p_i \partial p_j} \tag{3}$$

Formula (2) is much easier to apply as we do not need to go through the tedious process of calculating the elements of the inverse of the hessian of the production function. All we need to know are the cost and the relevant prices.

Since wheat production structure at the farm level is being studied, there will be need to determine the Allen partial elasticities of substitution between inputs; price elasticities of factor demands; and wheat output responses with respect to product and factor prices. Thus, a system of factor share equations and an output-supply equation will be estimated in this study. Parameter estimates from the factor share equations will permit calculation of elasticities of substitution and of factor demands. The output-supply function will permit determination of supply responses with respect to output price as well as variable factor prices.

It should be mentioned that unlike the cost function, the profit function imposes a strong behaviourial assumption regarding producers' objectives. The assumption of profit maximization by producers generally is not as likely in the real world situation as is the assumption of cost minimization implied by the cost function. Thus, the cost-function[11], and hence the factor shares that will be derived, constitutes the major aspect of the model that will be used in this study.

3.1 The Cost Function

In the simplest terms, Jorgenson (1986) defined the cost function as the minimum of the sum of expenditures on all inputs expressed as a function of the level of output and the price of all inputs.

For purposes of discussion of the cost function, hypothesize a representative firm (wheat farm) producing a single output Y according to the usual assumed concave production function

[11] Fuss and McFadden (1978) observed that the "subsequent work by McFadden (1964), Diewert (1969a,b), Christensen, Jorgenson and Lau (1971), and others have established the use of dual cost and profit functions as a basic tool in econometric production analysis".

$$Y=f(X) \tag{4}$$

where $X=f(x_1, \ldots, x_n)$. X denotes the input vector. We assume that the firm is a price taker in n factor markets. The existence of zero prices is ruled out. Thus, at the profit maximizing level of output Y and factor prices W, the firm is solving a cost minimization problem

$$\text{min.} \quad c(W,Y)=\sum w_i x_i \qquad s.t. f(X) \geq Y \tag{5}$$

where W is a vector of strictly positive input prices; and X and Y are as earlier defined.

Equation (5) defines the cost function, and as can be seen, the minimum cost, $C^* = c(W,Y)$ depends on the levels of input prices (W) and output (Y), as well as on the production function. The relation between the minimum cost C^* and parameters (W,Y), conditional on the firm's particular production function can in theory be traced out by solving (5) using different values of W, and Y.

3.2 Properties of the Cost Function

The cost function exhibits certain properties which are of interest in empirical research in the sense that some of these properties can be tested to determine producers' behaviour. The properties which are of relevance to this study will be briefly outlined here without any proof. Varian (1992), and Chambers (1991) provide proofs for these properties.

1. $c(W,Y) > 0$ for $W > 0$ and $Y > 0$. This simply means that the cost function is non-negative in factor prices as it is not possible to produce a

positive output at zero cost.

2. If $\hat{W} > W$, then $c(\hat{W}, Y) > c(W, Y)$. What is meant here is that the cost function is non-decreasing in factor prices. Increasing any input price must not decrease cost.

3. The cost function is concave and continuous in W. The concavity of the cost function follows solely from the hypothesis of cost-minimization and it has these implications: (a) the cross-price effects are symmetric; and (b) the own price effects are negative.

4. $c(tW,Y) = tc(W,Y)$, for $t > 0$. This implies that the cost function is positively linearly homogeneous. As long as input prices vary proportionately, the cost-minimizing choice of inputs will not vary. Put differently, only relative prices matter to economically optimizing agents.

5. If $Y > \check{Y}$, then $c(W,Y) > c(W, \check{Y})$. This means that the function is non-decreasing in Y. That is, increasing output cannot decrease the costs.

Properties 1, 2, 5, and more especially 4 are of great significance in this study in the sense that they can be tested to determine whether the wheat farmers' behaviour is consistent with cost minimization. Property 3 not only facilitates the determination of the farmers' behaviour but also facilitates the estimation of a system of share equations with relatively small sample sizes without necessarily risking degrees of freedom problems. Note that there is a gain in degrees of freedom when a system of equations with the same explanatory variables is estimated with symmetric conditions imposed.

There is one additional property of the cost function which is of critical importance in applied research. And it is no exception in this study. This has to do with the application of the Shephard's lemma given a differentiable cost function. Quoting Chambers (1991), "If the cost function is differentiable in *W*, then there exists a unique vector of cost-minimizing demands that is equal to the gradient of *c(W,Y)* in *W*. That is, if $x_i(W,Y)$ is the i^{th}, unique cost-minimizing demand, then

$$x_i(W, Y) = \frac{\partial c(W, Y)}{\partial W_i} \tag{6}$$

which is the Shephard's lemma."

The cost function approach is one possible approach in empirical work of the type undertaken in this study. The assumption that producers are minimizing costs is an assumption generally acceptable among researchers. From application of the cost function approach the elasticities of substitution among inputs are readily determinable as are producers' responses to changes in relative factor prices.

However, the approach has several limitations. It assumes that output is fixed from the producers' point of view. Thus, output levels are not affected by factor price changes and, thus, the indirect-effect of factor price changes on factor demands are ignored (Lopez,1982). Also, by including output as an explanatory variable, the econometric problem of simultaneous equation bias may arise if output levels were not exogenous. And lastly, the product price does not enter the cost function and hence its effect on output is ignored.

It should however be mentioned that problems not addressed by the cost function approach can be resolved by the adoption of the profit function approach though this would require a much stronger behaviourial assumption of profit maximization by producers as has already been indicated. As Lopez notes, this assumption "may be substantially more difficult to support in agriculture than simple cost minimization because of risk related problems which are mainly related to the variability of output yields and price rather than to costs of production". But if profit maximization is supported by the data, then simultaneous equation bias is avoided, and output supply responses can be jointly estimated with the factor demand equations (Lopez, 1985). Thus, the advantage afforded by the profit function approach is that factor demands estimated using a profit function framework facilitate the determination of input substitution and output scale effects of factor price changes as well as the determination of the cross effects of output price changes on factor demand plus output supply responses and their cross price effects.

3.4 Model Specification

This study utilizes a dual rather than a primal function. The motivation for adopting a dual approach emanates from the following considerations.

Firstly, the data base in Zambia generally is not good enough for some of the variables that may have to be included if a direct function were to be estimated. As will be seen in the next section of this chapter, data on fixed inputs were very limited. This would lead to a bias in econometric results if a production function approach were to be adopted as variable factor inputs and levels of fixed inputs are expected to be collinear. But for a dual function, variable factor prices are not expected to be collinear with levels of fixed inputs. As such, bias in econometric results would not be expected.

Secondly, the approach allows for more relaxed assumptions with regards to the underlying technology. As Binswanger (1974) notes, "It is not necessary to impose homogeneity of degree one on the production process to arrive at estimation equations. Cost functions are homogeneous in prices regardless of the homogeneity properties of the production function, because a doubling of all prices will double the costs but will not affect factor ratios".

Thirdly, theoretical properties of cost functions are more readily tested in the framework of dual functions.

And lastly, the dual approach eases estimation problems too. For instance, if a direct production function is specified and estimated, the variables that are omitted from the econometric model, but are observed by the producers, influence both the error terms and production decisions but do not necessarily influence factor prices (Varian, 1992).[12] If we estimate a direct production function, we are much more likely to face simultaneous bias problems. Therefore, to get efficient estimates, we should not estimate the production function directly, but estimate the factor demand functions and then infer the underlying technological structure. We can see from the foregoing why a dual, rather than a primal approach is more appealing in this study.

[12] Also, B.T. Coyle's lecture notes for *Forecasting and Simulation (61.740)* course.

3.4.1 Derivation of Factor Share Equations

An econometric model of producer behaviour takes the form of a system of simultaneous equations determining the distributive shares of inputs (Jorgenson, 1986). Measures of substitution give the response of the distributive shares to changes in input prices. These measures are treated as unknown parameters to be estimated.

Following Lopez and Tung (1982), we assume that in the Zambian wheat production industry, there exists a twice differentiable production function which relates the flow of output Y to the services of inputs:

$$Y=f(X) \tag{7}$$

where Y is output level; and X is a vector of inputs. Corresponding to this production function is a dual cost function which reflects production technology, which in the general form, is specified as

$$C=C(Y,W) \tag{8}$$

where C is the cost, and W is a vector of input prices.

To facilitate the analysis, a more flexible functional form is desirable: flexible in the sense that it imposes no a priori restrictions on the Allen partial elasticities of substitution, and can be interpreted as a second-order approximation to an arbitrary differentiable cost function (Lopez and Tung, 1982).

The Cobb-Douglas functional form imposes serious and to some degree, unrealistic restrictions on the production process (Varian, 1992). The form dictates that the elasticity of substitution between each pair of factors must be identically one. But there is no particular reason to impose such a restriction on apriori grounds.

The constant elasticity of substitution (CES) production function places somewhat fewer restrictions as compared to the Cobb-Douglas functional form. However, it too has its own shortcomings. Though it allows the elasticity of substitution between pairs of factors to differ from unity, it forces the elasticities between each pair of factors to be the same.

Although they can satisfy globally the concavity property implied by static competitive cost minimization, normalized quadratic cost functions do not provide flexible representations of production functions in the case of constant returns to scale (Coyle, 1989). This study thus utilizes the translog cost function as it does not impose these restrictions.

The translog cost function, in natural logarithms (ln), takes the form

$$\begin{aligned} lnc(W,Y) = \alpha_0 + \sum_i \alpha_i \ln w_i + \alpha_y \ln Y + \frac{1}{2}\sum_i \sum_j \beta_{ij} \ln w_i \ln w_j \\ + \sum_i \beta_{iy} \ln w_i \ln Y + \beta_{yy} (\ln Y)^2 \end{aligned} \tag{9}$$

The α and β are the parameters while W_i (or W_j) and Y are as earlier defined.

The conditional factor demands (6) are derived by applying Shephard's lemma to the cost function. These factor demands are not linear in the parameters, but we can derive from them factor shares which are linear in parameters. The shares are

$$s_i(W,Y) = \frac{w_i x_i}{C(W,Y)} = \alpha_i + \sum_j \beta_{ij} \ln w_j + \beta_{iy} \ln Y \tag{10}$$

for all $i = 1, \ldots, n$ where

$$\sum_i s_i(W,Y)=1 \tag{11}$$

Since s_i can be observed, equation (10) can be used to estimate the parameters of the function, and hence the corresponding production function. Since the shares are expressed as functions of prices and output, much simpler estimation methods such as the generalized least squares (GLS) may be employed (Pope, 1982).

A well behaved cost function must be linearly homogeneous in factor prices. In the context of the system of equations in (10), this requires that

$$\sum_i \alpha_i=1 \quad ; \quad \sum \beta_{ij}=0 \quad ; \quad \sum \beta_{ji}=0 \tag{12}$$

And the cross-price restrictions are given by

$$\beta_{ij}=\beta_{ji} \tag{13}$$

However, due to data limitations, only land was included in the model as a quasi-fixed input. Other fixed inputs (K) like machinery, buildings etc. were not.

Despite not having the fixed inputs included in the deterministic component of the model, bias in the econometric results was not expected because fixed inputs are often viewed as predetermined, and so, the covariance between output and the fixed inputs is small—that is $cov(Y,K)\approx 0$.

The translog cost function for this study was specified as

$$
\begin{aligned}
lnc(W,Y) = \alpha_0 + \sum_i \alpha_i \ln w_i + \beta_y \ln Y + \beta_h \ln H + \frac{1}{2}\sum_i \sum_j \beta_{ij} \ln w_i \ln w_j \\
+ \sum_i \beta_{iy} \ln w_i \ln Y + \frac{1}{2}\beta_{yy}(lnY)^2 \qquad (14) \\
+ \sum_i \sum_h \beta_{ij} \ln w_i \ln H_h + \frac{1}{2}\sum_i \sum_j \delta_{hj} \ln H_h \ln H_j
\end{aligned}
$$

The α, β and δ are the parameters; H is the area planted under wheat; and W_i (or W_j) and Y are as earlier defined.

The conditional factor demands (6) are derived by applying Shephard's lemma to the cost-function. These factor demands are not linear in the parameters but we can derive from them factor shares which are linear in parameters. The shares are

$$
s_i = \frac{W_i X_i}{C} = a_i + \sum_i a_{ij} \ln w_j + \beta_{iy} lnY + \delta_i \ln H \qquad (15)
$$

Here C is the total variable cost; and the factor shares are functions of the variable factor input prices, output levels and area planted under wheat.

Equation (15) constitutes the system of equations for factor shares estimated in this study.

3.4.2. Specification of the Output-Supply Equation

It was pointed out earlier that one of the limitations of the cost-function approach is that it assumes that output is fixed from the producers' point of view. Thus, output levels are not affected by factor price changes. The product price does not enter the function either. Its effect on output is therefore ignored. As such, the study objective of determining the producers' response in terms of output supply to changes in output price cannot be attained within the framework of the cost-function approach. Therefore, there is need to specify and estimate an output-supply equation. The discussion on how the output-supply function was derived follows.

Let

$$\max_y PY - C(W, K, Y) \quad (16)$$

be the profit function. K here is a quasi-fixed input. Since the cost-function is translog, and assuming profit maximization, (output) Y is multiplied to both sides of the equation; and then, the equation is divided by the cost (C) on both sides to arrive at

$$\frac{PY}{C} = \alpha_Y + \beta_{Y1}\ln w_1 + \beta_{Y2}\ln w_2 + \beta_{Y3}\ln w_3 + \beta_{Y4}\ln w_4 + \beta_{Y5}\ln w_5 + \beta_{Y6}\ln w_6 + \beta_{YY}\ln Y + \delta_Y \ln H + \varepsilon_Y \quad (17)$$

Total revenue (PY) divided by the total variable cost is a function of variable factor prices, output levels and hectarage under wheat. Equation (17) is the first-order condition of the profit function in terms of the translog cost-function. It is non-linear in Y, so it cannot easily be solved for Y, but it is easy to estimate. It was therefore tested as to whether it should be included with the factor share equations. How the test was conducted is briefly shown.

Equation (15) can be expressed in a more explicit form as

$$\begin{aligned} s_1 &= \alpha_1 + \beta_{11}\ln w_1 + \beta_{12}\ln w_2 + \beta_{13}\ln w_3 + \beta_{14}\ln w_4 + \beta_{15}\ln w_5 + \beta_{16}\ln w_6 + \beta_{1Y}Y + \delta_1 H + \varepsilon_1 \\ &\vdots \\ s_6 &= \alpha_6 + \beta_{61}\ln w_1 + \beta_{62}\ln w_2 + \beta_{63}\ln w_3 + \beta_{64}\ln w_4 + \beta_{65}\ln w_5 + \beta_{66}\ln w_6 + \beta_{6Y}\ln Y + \delta_6 H + \varepsilon_6 \\ \frac{PY}{C} &= \alpha_Y + \beta_{Y1}\ln w_1 + \beta_{Y2}\ln w_2 + \beta_{Y3}\ln w_3 + \beta_{Y4}\ln w_4 + \beta_{Y5}\ln w_5 + \beta_{Y6}\ln w_6 + \beta_{YY}\ln Y + \delta_Y \ln H + \varepsilon_Y \end{aligned} \quad (18)$$

where s_1, s_2, s_3, s_4, s_5 and s_6 are cost shares for seed-wheat, basal dressing fertilizers, chemicals, top dressing fertilizers, labour and fuel for farm machinery respectively. Equations s_1 through s_6 are the estimating factor shares in (15) while the last equation is the output-supply equation—equation (17). Equations (15) and (17) were estimated simultaneously and the output coefficients in the share equations (15) were tested as to whether they were equal to the corresponding coefficients in the supply equation (17). The tests were $\beta_{1Y}=\beta_{Y1}$; $\beta_{2Y}=\beta_{Y2}$; $\beta_{3Y}=\beta_{Y3}$; $\beta_{4Y}=\beta_{Y4}$; and $\beta_{5Y}=\beta_{Y5}$. The equality between $\beta_{6Y}=\beta_{Y6}$ was not tested because the sixth share equation was dropped out during estimation to avoid simultaneity. The test was rejected and it was thus concluded that equation (17) should not be included with the factor shares. Thus, an alternative supply equation was specified.

Though agricultural economists often favour modelling crop production decisions in terms of acreage responses rather than output supplies (Coyle,1993), this study placed more emphasis on output-supply. The major reasons being:- firstly, wheat in Zambia is an irrigated crop produced during the dry season. As such, it is arguable that weather does not cause much uncertainties regarding the desired output levels since farmers know the amount of water reserves that they have prior to planting. And secondly, the need to at least have an approximation of the impact of wheat price on wheat output.

Since product-price (P) is not expected to be collinear with levels of fixed inputs, the covariance between them was expected to be approximately zero— that is $\text{cov}(P, K) \approx 0$. In modelling the output-supply function, this condition implies that

$$Y=\alpha_0+\alpha_1\frac{P}{W_0}+\sum_i \alpha_{i+1}\frac{W_i}{W_0}+\delta_Y H \tag{19}$$

Output-supply is thus a function of output price and variable factor prices normalized by one of the factor prices, and the area planted under wheat. The α_s are the response coefficients. This is the output-supply equation that was estimated in this study.

3.4.3 Acreage Response Equations

Two equations were specified and estimated jointly to determine the response of hectarage to changes in wheat price. These equations were specified as follows:

$$\frac{Y}{H}=\alpha_0+\alpha_1\frac{P}{W_0}+\sum_i \alpha_{i+1}\frac{W_i}{W_0}+\delta_Y H \tag{20}$$

and

$$H=\alpha_0+\alpha_1\frac{P}{W_0}+\sum_i \alpha_{i+1}\frac{W_i}{W_0} \tag{21}$$

In equation (20), output level divided by wheat hectarage is a function of the normalized product and factor prices as well as wheat hectarage. In equation (21), wheat hectarage is a function of normalized product and factor prices only. The price coefficient in equation (21) indicates the response of hectarage to changes in wheat product price.

3.5 Variable Definitions

The variables included in the cost-function part of the model are expenditure shares for seed-wheat (S_1), basal dressing fertilizers (S_2), chemicals (S_3), top-dressing fertilizers (S_4), labour (S_5), and fuel (S_6) for the dependent variables. The explanatory variables are input prices for seed-wheat (W_1), basal dressing fertilizers (W_2), chemicals (W_3), top-dressing fertilizers (W_4), labour (W_5) and fuel (W_6). Wheat hectarage and output-levels were also included as explanatory variables. The variable inputs considered are the inputs that the Ministry of Agriculture as well as the Commercial Farmers Bureau[13] consider to be the most important in influencing wheat production.

In the output-supply function part of the model, output level (Y) is the dependent variable while the normalized prices of wheat, seed-wheat, basal dressing fertilizers, chemicals, top dressing fertilizers and labour as well as wheat hectarage are the explanatory variables. Prices were normalized by fuel price.

[13] The Commercial Farmers' Bureau is a lobbying organization for farmers. Of late, it has exerted a great deal of influence in shaping government policy in the sector.

CHAPTER 4

DATA AND ANALYTICAL PROCEDURE

This chapter discusses how data for the study was collected. The other concern of the chapter is to describe the procedure that will be used in the analysis.

4.1.0 Data Collection and Description

The study utilizes pooled cross-section and time series data. The data set pertain to thirty six farmers over a four year period—1988 to 1991. By using this kind of data, we assume that the economic agents are homogeneous except for the differences arising from other factors explicitly introduced in the model (Koutsoyiannis, 1984).

As noted by Koutsoyiannis (1984), time series data are more appropriate on theoretical grounds for the estimation of economic relationships. But in the absence of time series data, one may have no choice but to resort to pooling cross section and time series data sets.

However, in many instances, models estimated using pooled data give results that are superior to those estimated using time series or cross section data alone. Besides giving the researcher a large number of data points which increases the degrees of freedom, pooling cross section and time series data may help reduce the collinearity among explanatory variables (Hsio, 1986; Koutsoyiannis, 1984). This improves the efficiency of econometric estimates. Also, aggregation bias is avoided if variables like expenditures across economic units are included in the model.

Most of the data that were used in the study are primary farm level data. The data were collected through a survey that was conducted among wheat farmers in Lusaka, Mazabuka and Kabwe areas of Zambia. Also, a few farmers in Ndola, Choma, Livingstone and Chipata areas did provide data. The whole exercise was done over a two-month period.

To facilitate the data collection process, a brief questionnaire was constructed and mailed to farmers for them to complete and return. Also, some direct interviews were conducted to speed up the process.

The data farmers were asked to provide over the period 1987 to 1991 pertained to input quantities and total expenditures on variable inputs as well as farm size, wheat hectarage and output levels (see questionnaire in appendix D). The variable inputs consisted of seed-wheat, fertilizers, chemicals, fuel, labour and other variable costs (combining and electricity expenses). The types of fertilizers used for wheat production are compounds D, C, and to a lesser extent X for basal dressing; and urea and ammonium nitrate for top dressing. A few farmers indicated use of ammonium sulphate for top dressing. For chemicals, farmers use any or a combination of any of these: 2,4-D Amine, MCPA, and Buctril M. No farmer reported using lime. They claimed that they limed the soil as they irrigated.

The standard measures for these inputs are: 50 kilogram bags for seed-wheat and fertilizers; liters for chemicals and fuel; and man-days for labour. The prices quoted are unit prices in Zambian currency for each of the inputs.

Most farmers could readily provide data for the period 1988 to 1991. For the earlier years, some could not provide data. They gave reasons such as: they could not easily retrieve their files and hence could not provide them; a few said it was pointless to keep records over a longer period when inflation was so high. However, quite a few provided very detailed information for all the years requested. Because some farmers did not provide information for the entire period (1987 to 1991), the data set used for the study is for the period 1988 to 1991. Following revision in the time period, questionnaires from thirty-six (36) farmers of the forty-five collected could be used. Another reason for leaving out some of the nine questionnaires is that they were poorly completed.

4.1.1 Factor Prices

Since the study is using pooled cross-section and time series data, price variations needed for the estimation of the econometric model came from the various types of basal and top dressing fertilizers and chemicals that each individual farmer used in the respective years. As such, during the data collection process, particular attention was paid to the various types of fertilizers and chemicals that each farmer used during the period under study. Also, the geographic location of each farmer was noted. This enabled us to attach appropriate prices of each factor input to each particular farmer. Note that fertilizer and chemical prices varied across types, and to some extent by geographic location. Fuel price and the wage-rate also varied by geographic location. Seed-wheat prices varied from source to source.

Put differently, factor prices for the individual farmers were collected directly. In the questionnaire, data on both input quantity usage and expenditures were requested for the purpose of counter-checking the degree of accuracy of the information provided. In Zambia, it is not uncommon for some farmers to give exaggerated expenditure figures. Since factor price data were collected directly, and quantity usage is known, then, it was possible to have an idea of which expenditure figures were exaggerated.

Time series data on output and variable input prices; interest rates; exchange rates; inflation rates; the CPI; and the floor price for wheat were collected from the Ministry of Agriculture; Central Statistical Office; and the Commercial Farmers' Bureau. The wheat price that farmers actually received was collected from National Milling Company, a parastatal company that buys most of the wheat marketed. Total expenditures on the respective input quantities, and thus expenditure shares were derived by multiplying input quantities by the appropriate prices.

4.2 Analytical Procedure

4.2.1 Factor Share Equations

For estimation purposes, the system of equations (15) was developed into stochastic form by assuming that the observed input demands are distributed stochastically along the expansion path (Lopez and Tung, 1982). Since Shazam Econometrics Computer Program version 6.2 has no provision for pooling data in a system of equations, the data set was entered into the program following the discussions provided by Kmenta (1986, pp616-7), and Johnston (1984, pp396). Accordingly, the data were organized and entered by decision (producers) units. That is, from year 1 to year 4, all data on producer one were entered in successive time periods, followed by all data on producer two, and so on and so forth.

The sample size was from 1 to 144—that is, thirty-six decision units multiplied by four year time-periods. Given that there are eight explanatory variables in equation (15), there are 1152 observation points altogether in the model.

Written explicitly, the estimating equations for the model took the form

$$\begin{aligned} s_1 &= \alpha_1 + \beta_{11} lnw_1 + \beta_{12} lnw_2 + \beta_{13} lnw_3 + \beta_{14} lnw_4 + \beta_{15} lnw_5 \\ &\quad + \beta_{16} lnw_6 + \beta_{1Y} Y + \delta_1 H + \varepsilon_1 \\ &\vdots \\ s_6 &= \alpha_6 + \beta_{61} lnw_1 + \beta_{62} lnw_2 + \beta_{63} lnw_3 + \beta_{64} lnw_4 + \beta_{65} lnw_5 \\ &\quad + \beta_{66} lnw_6 + \beta_{6Y} lnY + \delta_6 H + \varepsilon_6 \end{aligned} \tag{22}$$

where s_1, s_2, s_3, s_4, s_5 and s_6 are cost shares for seed-wheat, basal dressing fertilizers, chemicals, top dressing fertilizers, labour and fuel for farm machinery respectively. The w_i, i = 1,...,6 are the respective factor prices; α, β and δ are coefficients; and ε is the disturbance term. The disturbance terms were assumed to have zero mean and correlated across equations. They were however assumed to be serially uncorrelated. That is,

$$E(\varepsilon_{it})=0 \quad ; \quad E(\varepsilon_{it}\varepsilon_{js})=\sigma_{ij} \quad for\ t=s \quad ; \quad E(\varepsilon_{it}\varepsilon_{js})=0 \quad for\ t\neq s \tag{23}$$

Given these properties, Zellner's seemingly unrelated regression (SUR)'s estimators are asymptotically efficient.

During estimation, the share equation for fuel was dropped out to avoid simultaneity problems. Since the sum of the cost shares automatically add up to total costs identically, the matrix of explanatory variables has no inverse and therefore no unique solution exists (Deaton, 1986). Therefore, to ensure that a unique solution existed one equation had to be dropped. Conceptually, it does not matter which share equation is dropped out. The fuel equation was dropped out just because it is fuel price that was used to normalize prices in the output-supply equation. The parameter estimates of the input prices and the constant of the dropped out equation were recovered by applying the linear homogeneity and the symmetric properties of the cost-function. Thus, most of the information was recovered from the dropped out equation.

Prior to being imposed, the theoretical restrictions (12) and (13) were tested. And both were not rejected at 5 percent significance level. Since data did not reject these restrictions, they were imposed during estimations. Restriction (13) ensures the uniqueness of estimated parameters which occur in more than one equation.

4.2.2 Output-Supply Equation

To determine supply response, equation (19) was also developed into stochastic form. In natural logarithms, it took the form

$$\begin{aligned} lnY = {} & \alpha_0 + \alpha_1 lnP^{\nabla} + \alpha_2 lnw_1^{\nabla} + \alpha_3 lnw_2^{\nabla} + \alpha_4 lnw_3^{\nabla} + \alpha_5 lnw_4^{\nabla} \\ & + \alpha_6 lnw_5^{\nabla} + \delta_Y lnH + \varepsilon \end{aligned} \qquad (24)$$

where P^{∇} is the normalized wheat product price; w^{∇}_i for i = 1,...,5 are the respective prices of seed-wheat, basal dressing fertilizers, chemicals, top dressing fertilizers and labour normalized by fuel price; and α and δ are the response coefficients. The product price was modelled as the price offered by the National Milling Company (NMC) lagged one year time period—that is, $P^{\nabla}=P_{t-1}$. The disturbance term, ε was assumed to possess standard statistical properties. As such, simple ordinary least squares estimation procedure was applied to the function.

Like the system of factor share equations (22), the sample size for the output-supply equations from 1 to 144 with 1008 observation points for the seven explanatory variables.

4.2.2.1 The Wheat Product Price

The wheat product price used in equation (24) is the price offered by the NMC lagged one year time period as opposed to the floor price which the government announces before the beginning of each season. This is because of the large differences between the NMC price and the floor price. For instance, in 1988, the floor price was at the same level as the NMC price lagged one year time period. After 1988, even the NMC lagged price was almost 100 percent higher than the floor price. Because of these differences, lagged NMC price was found to be more appropriate. Appendix C gives a comparison of the two price.

4.3 Elasticity Calculations

To understand the wheat production structure, one calculates, from the estimated parameters, the Allen partial elasticities of substitution and elasticities of factor demands. For this formulation, the Allen partial elasticities for own and cross-prices are respectively calculated as (Binswanger, 1974)

$$\sigma_{ii} = \frac{1}{s_i^{a2}} (\beta_{ii} + s_i^{a2} - s_i^a)$$
$$\sigma_{ij} = \frac{1}{s_i^a s_j^a} \beta_{ij} + 1 \qquad (25)$$

The own and cross price elasticity of factor demands are respectively calculated as

$$\eta_{ii} = \frac{\beta_{ii}}{s_i^a} + s_i^a - 1 \ ; \quad \eta_{ij} = \frac{\beta_{ij}}{s_i^a} + s_j^a \qquad (26)$$

where the betas are coefficients estimated from equation (22), and the s^a_i or s^a_j are the respective average cost shares. The elasticity of wheat output with respect to own price was estimated from the output-supply equation (24).

4.4 Acreage Response Equations

As was mentioned in chapter 3.5, acreage response equations were specified to determine acreage response to changes in the product price. These equations (20) and (21) were estimated simultaneously using three stage least squares estimation procedure. This procedure was used because wheat hectarage appears in as an independent variable in (20) and as a dependent variable in (21).

4.5 Hypotheses Testing

Several hypotheses were tested regarding wheat producers' behaviour. Firstly, the hypothesis that producer behaviour did approximate cost-minimization for any given level of wheat output was tested. This was accomplished by testing for the symmetric property of the cost function. The test was

$$\beta_{ij} = \beta_{ji} \quad for \ all \ i,j \ ; \ i \neq j \qquad (27)$$

against the alternative hypothesis that

$$\beta_{ij} \neq \beta_{ji} \tag{28}$$

for at least one of the i,j.

Theoretically, if condition (27) holds, then, negative semi-definiteness of the Hessian matrix should be tested. The test is whether

$$h^{T}\left[\frac{\partial^2 C(W,Y)}{\partial w \partial w}\right]_{nXn} h \leq 0 \tag{29}$$

for all h where $h=(h^{i},\ldots,h^{N})$ and $i=1,\ldots,N$. Presence of the negative semi-definiteness of the Hessian matrix is the necessary and sufficient second-order condition for cost minimization. As will be discussed in section 5.6, condition (29) was not tested as the test result of (27) and that of linear homogeneity (12) of the cost-function were considered satisfactory to conclude approximation to cost-minimization.

Secondly, the hypothesis that increases in factor prices individually or jointly have no significant influence on wheat output-supply was tested. The hypothesis test for individual factor prices was

$$\frac{\partial Y}{\partial w_i} = 0 \tag{30}$$

for all i = 1 ,..., 6 against the alternative hypothesis that

$$\frac{\partial Y}{\partial w_i} \neq 0 \tag{31}$$

The joint hypothesis test was

$$\frac{\partial Y}{\partial w_i}=0 \qquad (32)$$

all i, for i = 1 ,..., 6 against the alternative hypothesis that

$$\frac{\partial Y}{\partial w_i}\neq 0 \qquad (33)$$

for at least one i.

And lastly, the hypothesis that wheat price has no significant impact on output supply was tested. The hypothesis test was

$$\frac{\partial Y}{\partial P}=0 \qquad (34)$$

against the alternative hypothesis that

$$\frac{\partial Y}{\partial P}\neq 0 \qquad (35)$$

The test results for the second and last hypotheses were determined from the *t* and *F* test statistics obtained from the output-supply equation (24).

CHAPTER 5

EMPIRICAL ESTIMATIONS AND ANALYSIS OF RESULTS

This chapter presents and discusses the results obtained from empirical estimations. The treatment of the analysis is as follows: firstly, the results of the factor share equations are discussed. The test results of the basic theoretical restrictions are also presented. This will be followed by a discussion of the results of the output-supply equation as well as the results of the stated hypotheses. The chapter winds up by drawing conclusions from the results as well as suggesting possible policy options to boost wheat output.

5.1 Factor Share Equations: Results

The system of equations (22) was fit to the data. As was mentioned earlier, the theoretical restriction of linear homogeneity of the cost function (12) and the symmetric restriction (13) were both not rejected at 5 percent level of significance. The value of the test statistic was -0.15 compared to the critical value of -1.96 at 95 percent confidence interval with 675 degrees of freedom for the homogeneity test. This means that as long as factor prices only vary proportionately, the cost-minimizing choice of inputs will not vary. The F-statistic for the symmetric test was (1.04) compared to the critical value 2.34 for 10 and 675 degrees of freedom. Since the data did not reject these restrictions, both of the restrictions were imposed on the estimated equations. The parameter estimates of the restricted model are given in table 1 below.

Table 1: Wheat Production in Zambia: Share Equation Estimates for Variable Inputs, 1988-1991 .

Share Equation	Constant	Price of Seed-wheat	Basal fert'zers	Chemicals	Top fert'zers	Labour	Fuel	Output Level	Hectarage	R^2
Seed-wheat	0.424* (0.143)	0.084* (0.034)	-0.041** (0.024)	-0.016* (0.006)	-0.037* (0.018)	-0.040** (0.021)	0.008 (0.024)	-0.060* (0.012)	0.066* (0.013)	0.34
Basal-ferts	0.020 (0.145)	-0.041** (0.024)	0.170* (0.037)	-0.024* (0.007)	-0.061* (0.020)	-0.015 (0.027)	-0.053** (0.027)	0.048* (0.017)	-0.042* (0.019)	0.24
Chems.	0.056 (0.045)	-0.016* (0.006)	-0.024* (0.007)	0.054* (0.004)	-0.006 (0.005)	0.007 (0.008)	0.004 (0.011)	-0.006 (0.008)	0.009 (0.008)	0.66
Top-ferts	0.046 (0.094)	-0.037* (0.018)	-0.061* (0.020)	-0.006 (0.005)	0.128* (0.019)	-0.012 (0.016)	-0.002 (0.017)	0.020* (0.010)	-0.019** (0.011)	0.28
Labor	0.462* (0.149)	-0.040** (0.021)	-0.015 (0.027)	0.007 (0.008)	-0.012 (0.016)	0.080* (0.034)	0.018 (0.031)	-0.018 (0.022)	-0.015 (0.024)	0.13

Note:

- Standard errors are in the parentheses.
- One asterisk indicates statistical significance at 5 percent significance level.
- Two asterisks indicate statistical significance at 10 percent significance level.
- The sample size is from 1 to 144. That is, thirty-six decision units multiplied by four year time-periods. Given that there are eight explanatory variables, there are 1152 observation points altogether in the model.

Of the forty estimated coefficients, eighteen are statistically significant at 5 percent significance level, and twenty-four are significant at 10 percent level of significance. All own factor prices are statistically significant at 95 percent confidence level. Except for the fuel coefficient which is negative, all own factor prices show a positive relationship to their respective expenditure shares suggesting that, at the very least, farmers do not reduce factor usage despite the increase in variable factor price levels. As such, we do not expect output to decline due to increases in factor prices. This has a positive implication for output expansion as it suggests that farmers would not reduce factor usage, and hence output levels even if factor prices rise as long as there are factors off-setting the impact of such increases. As for fuel, the results suggest that its usage declines as fuel price rises.

As was mentioned in chapter 4.2.1, the parameter estimates of the fuel equation were recovered by applying the homogeneity and symmetric properties of the cost-function. The own-price coefficient for fuel was -0.012 .

The coefficients of output levels in all but the chemicals and labour equations are significant at 5 percent significance level. Another observation regarding the coefficients of the output level is that, with the exception of the top and basal dressing fertilizers, they all show a negative relationship with respect to their expenditure shares.

The hectarage variable shows significance at 5 percent significance level in the seed-wheat and basal fertilizers share equations. In the top-dressing fertilizers share equation, it is significant at 90 percent confidence level—it is not in the chemicals and labour share equations. The results thus suggest that as hectarage increases, seed-wheat and chemicals expenditure shares increase while expenditure shares of basal and top fertilizers and of labour decline proportionately.

5.2 Substitution and Factor Demand Elasticities

For the purposes of policy making, elasticities of substitution as well as elasticities of factor demands are very important. Thus, since we intend to suggest policy recommendations aimed at expanding wheat output, we need to come up with elasticity estimates.

Elasticities of substitution for own and cross-prices were determined using formulae (25). Price elasticities of factor demands for own and cross-prices were calculated using formulae (26). Note that elasticities of substitution and cross-price elasticities of factor demands are positive for substitutes and negative for compliments.

Tables 2 and 3 show the Allen partial elasticities of substitution and the elasticities of factor demands respectively. Except for top fertilizers whose own-price elasticity is positive, all own elasticities of substitution have the theoretically correct signs. They are negative. Seed-wheat and basal fertilizers have been portrayed as substitutes; seed-wheat and chemicals as compliments; seed-wheat and fuel as substitutes; seed-wheat and labour as compliments and seed-wheat and top dressing fertilizers as compliments. As for basal dressing fertilizers, complimentary relationship was portrayed with chemicals, top fertilizers and fuel; and a substitute relationship with labour. As for chemicals, a substitute relationship was portrayed top-dressing fertilizers, labour and fuel. Also for top fertilizers, a substitute relationship was portrayed for both labour and fuel. And finally, labour and

Table 2. Wheat Production in Zambia: Allen Partial Elasticities of Substitution

Factor input	Price of Seed-wheat	Basal ferts.	Chemicals	Top ferts.	Labour	Fuel
Seed-wheat	-1.960	0.317	-0.398	-0.466	-0.485	1.355
Basal fert'zers	0.317	-0.471	-0.089	-0.251	0.716	-0.280
Chemicals	-0.398	-0.089	-1.418	0.314	1.665	1.574
Top fert'zers	-0.466	-0.251	0.314	0.316	0.448	0.893
Labour	-0.485	0.716	1.665	0.448	-2.133	0.965
Fuel	1.355	-0.280	1.574	0.893	0.965	-8.018

Table 3. Wheat Production in Zambia: Elasticities of Factor Demands

Factor input	Price of Seed-Wheat	Basal ferts.	Chemicals	Top fert.	Labour	Fuel
Seed-wheat	-0.348	0.108	-0.026	-0.066	-0.074	0.165
Basal fert'zers	0.056	-0.161	-0.006	-0.036	0.109	-0.034
Chemicals	-0.071	-0.030	-0.092	0.044	0.254	0.192
Top fert'zers	-0.083	-0.086	0.020	0.043	0.068	0.109
Labour	-0.086	0.244	0.108	0.064	-0.326	0.240
Fuel	0.240	-0.095	0.102	0.127	0.300	-0.978

fuel were portrayed as substitutes.

A closer examination of these elasticities reveals that the degree of complementarity or substitutability is low considering that the elasticity of substitution can take any value between negative and positive infinite. With an elasticity value of 1.66, labour and chemicals have the highest degree of substutability while labour and seed-wheat have the highest degree of complementarity (-0.485). Labour seems to be a more likely input to be substituted for other variable inputs. Chemicals, fuel and basal and top dressing fertilizers can be substituted for labour. Labour is a compliment only for seed-wheat with a value of

-0.485. Thus, in situations where there is shortage of other variable inputs (which to a large extent are imported), it would still be possible to expand wheat output as long as labour is readily available, and conversely, with easy accessibility of these other inputs, labour can easily be replaced without adversely affecting output.

As for the values of own-price elasticities of substitution, except for top and basal fertilizers whose respective elasticity values are 0.013 and -0.471, all have absolute values which are greater than one. With own-price elasticity of -8.018, fuel usage seems to be the most sensitive to own-price changes. It is followed by labour (-2.133); seed-wheat (-1.960) and chemicals (-1.416). Basal fertilizers have the lowest degree of substutability.

Another interesting observation about these own-price elasticities of substitution is the positive sign taken on by the top fertilizers. It suggests that even if the relative price of top fertilizers falls, its usage does not increase.

Again with the exception of top fertilizers, all own-price elasticities of factor demands in table 3 are negative. This is what is expected apriori. With own-price elasticity of -0.978, fuel usage declines in almost the same proportions as increases in its own price. Except for own-price for fuel, the absolute values of both own and cross-prices are very much less than one implying that factor price changes do not have much impact on factor demands. This suggests that variable factor usage, and therefore output is not adversely affected by increases in prices of variable inputs.

Portraying a positive own-price elasticity of factor demand, the results suggest that the top fertilizers factor are an inferior input. Their usage increases along with increases in its price.

5.3 Results of the Output-Supply Equation

As was mentioned earlier, one of the limitations of the cost-function approach is that the product price does not enter the function, and hence its effect on output is ignored. This limitation was resolved by estimating an output-supply equation (24) whose results are presented in table 4 below.

The results show that the price of wheat, lagged by one year time period, is statistically significant at 10 percent level of significance. The results thus suggest that output price has a significant influence on wheat output. All variable factor prices, individually or jointly, were not statistically significant even at 10 percent significance level. Thus, variable factor prices had no significant influence on wheat output. Hectarage shows a direct relationship with output. Furthermore, it is statistically significant even at 99 percent confidence level.

Table 4: Wheat Production in Zambia: Output-Supply Equation Estimates, 1988-1991.

Variables	Estimated Coefficient	T-Ratio	R^2=0.87
Normalized price of			
Wheat	0.084** (0.050)	1.679	
Seed-Wheat	0.146 (0.235)	0.624	
Basal fertilizers	-0.146 (0.203)	-0.720	
Chemicals	0.026 (0.041)	0.646	
Top fertilizers	0.017 (0.179)	0.095	
Labour	0.105 (0.191)	0.550	
Hectarage	1.030* (0.036)	28.926	
Constant	2.846* (0.916)	3.107	

Note:

- Standard errors are in parentheses.
- Like the system of factor share equations, the sample size for the output supply equation is from 1 to 144 with 1008 observation points for the seven explanatory variables.

These results are consistent with the results obtained for the system of share equations (22). The estimated parameters of the share equations revealed that, except for fuel, farmers do not reduce factor input usage even if there is an increase in variable factor prices. Relating this to the supply equation, it seems that the increases in the product price have been sufficient to offset the adverse impact of increases in factor prices on wheat output. The implication this result has for policy formulation is that government need not provide subsidies at least on variable inputs as long as the product price is sufficiently high.

Whilst on this point, we should perhaps mention the sentiments that some farmers revealed during the data collection process. Those who commented on wheat pricing expressed a great deal of satisfaction. They argued that it was favourable because, among other things, it took into account import-parity. This protected the producers from wheat imports especially during the period when wheat imports were allowed to enter the Zambian market.

5.3.1 Output-Supply Elasticities

For policy purposes, we need to determine both the direction and magnitudes of supply response to wheat price changes. The results show a positive relationship between wheat output and the output price as one would expect a priori. As for price elasticity of supply, the output price coefficient is at the same time the elasticity since the supply equation was estimated in a double-log form. Its value is 0.084 indicating that output supply is not responsive to wheat price changes. This result concurs with the observation made by Tomek and Robinson (1990) when they argued that changes in aggregate farm output overtime are associated mainly with shifts in the production function (pp307) while trends in agricultural prices are associated with general inflation and deflation in the economy (pp165). The implication that this result has for policy is that, to boost output, government policy should emphasize a great deal on technological innovations and/or adoption.

The results however suggest that output-supply is responsive to changes in hectarage—the elasticity is 1.03. This is in agreement with the results obtained by some unpublished studies which argued that, agricultural expansion in Zambia is in general associated mainly with expansion in area cultivated rather than increases in yields per hectare. However, as for the wheat sub-sector, one would argue that the scope for increasing yields per hectare is very limited as yield levels are already favourably high. The Department of Agriculture puts the national average of wheat yield per hectare at 5 to 6 metric tonnes (mt) while many farmers in this study indicated having attained as high as 8 mt, and, one farmer indicated having attained 9.5 mt.

5.4 Results of the Acreage Response Equations

The results of equations (20) and (21) estimated jointly are shown in appendix A. For the equation (20) in which output level divided by hectarage is the dependent variable, wheat product price, lagged one year time period, is statistically significant at 90 percent confidence level. It is the only variable showing significance in the whole equation. In the equation (21) in which wheat hectarage is the dependent variable, wheat product price is not significant at all though directly related to hectarage. Seed-wheat price is inversely related to hectarage and is significant even at 5 percent significance level. The other variable which is significant even at 5 percent significance level is the wage-rate. It is portrayed as having a direct relationship with hectarage though one would expect otherwise.

That wheat product price is not significant even at 10 percent significance level is not surprising. Since wheat in Zambia is an irrigated crop, any expansion in hectarage must be preceded by additional investments in irrigation facilities. Such investments take time. As such, the impact of wheat price may only be manifested after a much longer time periods.

5.5 Stated Hypotheses: Test Results

As was mentioned in sections 1.4.2 and 4.4 several hypotheses regarding the behaviour of wheat producers were tested.

The hypothesis that farmer behaviour did approximate cost-minimization was tested. One of the necessary conditions for cost minimization is that the symmetric restriction (27) holds. The test result showed that the restriction holds. The test statistic obtained was 1.04 compared to the F-critical of 2.34 for 10 and 675 degrees of freedom. Since the symmetric test was not rejected, a further test—the test for negative semi-definiteness of the Hessian matrix (condition 29) was necessary to reach a decisive conclusion as to whether producer behaviour was indeed consistent with cost-minimization.

But as was indicated in section 4.5, the test for negative semi-definiteness of the Hessian matrix was not conducted as the result of the symmetric test coupled with the test result of linear homogeneity of the cost-function was considered satisfactory to conclude approximation to cost-minimization among wheat producers in Zambia.

Secondly, the hypothesis that variable factor prices, either individually or jointly, had no significant influence on wheat output was not rejected at 1 percent significance level. The F-statistic obtained for the joint test was 0.333 compared to the critical value of 2.27 for 5 and 136 degrees of freedom. Also, evaluating the t-ratios for the supply equation (21), revealed that no variable factor price was statistically significant even at 90 percent confidence interval. It was therefore concluded that increases in variable factor prices had no adverse impact on wheat output in data range studied.

And lastly, the hypothesis that wheat output price had no significant influence on output was rejected at 10 percent significance level, but it was not rejected at 5 percent significance level. The test statistic obtained was 1.679 compared to the t-critical value of 1.64 for 136 degrees of freedom. Thus, to a certain degree, the product price has a significant and positive impact on output—an increase in output price leads to an increase in output ceteris paribus.

5.6 Conclusions from the Results

From the foregoing, a number of conclusions regarding economic factors affecting wheat production in Zambia were reached for the period under study. The conclusions were as follows starting with those drawn from the cost function approach.

(a). From the parameter estimates of the cost-function, these were the conclusions drawn regarding wheat producers' behaviour viz-á-viz increases in variable production costs:

(i). The results tend to suggest that wheat producers behaviour is consistent with cost minimization. The symmetric restriction test was not rejected at 5 percent level of significance. Also, the theoretical restriction of linear homogeneity of the cost function was not rejected implying that only relative factor price changes matter to optimizing economic agents.

(ii). Except for fuel, the increases in price levels of variable factors do not lead to a reduction in factor usage as coefficients of own factor prices are positive. Thus, output levels are not expected to decline as a result of increases in factor price levels.

(iii). With regards to increases in hectarage viz-á-viz factor usage, it was observed that as hectarage increases, seed-wheat and chemicals expenditure shares increase while expenditure shares of basal and top fertilizers and of labour decline proportionately.

(iv). Except for top-fertilizers, the own-price elasticities of substitution have the theoretically correct signs. They are negative. The factor labour is a substitute for chemicals, fuel, basal and top fertilizers. The degree of substitutability is much lower for basal fertilizers as compared to fuel, chemicals and top fertilizers. Labour is a compliment for seed-wheat. If supplies of these inputs were to be limited, to some extent, wheat production would not be adversely affected as long as labour is readily available.

(v). Still on elasticities, it was noted that fuel, followed by labour are the most sensitive to own price changes. It was therefore concluded that fuel and labour saving production techniques are most appropriate.

(vi). As for elasticities of factor demands, both own and cross price elasticities are much lower than one in absolute terms. Thus, factor price changes have little impact on variable factor demands. The only exception is own-price for fuel whose price elasticity is close to unit.

(b). From the estimates of the output-supply function, the following conclusions regarding the response of wheat supply to changes in product and factor prices were drawn:

(i). Changes in wheat price have a positive impact on wheat output. Thus, to some degree, price can be used as an instrument in facilitating expansion in output.

(ii). All factor prices had no significant influence on output. This was true even in the case where their influence was considered jointly. It seems that the increases in wheat price were sufficiently high to off-set the impact of increases in variable factor prices.

(iii). Though wheat price has a significant impact on output, output-supply is not very responsive to price changes. This leads to the conclusion that wheat price alone is not sufficient for expansion of wheat output. Other factors affecting production seem to matter in a significant way.

(iv). Wheat output is responsive to changes in hectarage as the elasticity is greater than one.

5.7 Policy Recommendations

The main objective of the study was to have a deeper understanding of the behaviour of wheat producers with a view to facilitate policy recommendations possible for boosting wheat output in Zambia. The government policy in the wheat sub-sector calls for self-sufficiency in wheat products. Based on the results obtained from empirical estimations, the study suggests the following policy recommendations.

(a). Considering that output is not significantly influenced by factor prices but by output price, it is recommended that government need not provide subsidies on variable factor inputs as long as wheat price is sufficiently high.

(b). The government policy should emphasize adoption of technologies that are labour and fuel saving. These are the factor inputs that are most sensitive to own-price changes. Furthermore, labour is a more likely substitute for most of the other variable inputs.

(c). The current pricing policy should be continued. It seems that it has been favourable as far as facilitating increases in wheat production are concerned.

(d). Wheat output is responsive to changes in hectarage but not to the product price. The study therefore suggests that government policies could be geared towards facilitating entry into the industry. This can be achieved through easy accessibility of the necessary infrastructure—easy accessibility of electricity supply for farm power for instance; and provision of subsidies on fixed inputs like development of water supplies for wheat irrigation, and farm equipment and machinery. Easy accessibility of these facilities would enhance farmer productive capacities. Also, provision of subsidies on fixed inputs would arguably encourage entry in the industry. We note that the number of wheat growers in the country is currently small. It has been around 70 between 1985 and 1992 (see appendix B) as compared to crops like maize where the number of growers has been some 600,000. More producers would mean more output.

(e). Given (d) above, it follows that emphasis on technological innovations and/or adoption to bring about outward shifts in producers' production functions may be effective policy instruments.

CHAPTER 6

SUMMARY AND LIMITATIONS OF THE STUDY

This chapter gives a cursory view of the entire study. It gives summaries of the problem statement and study objectives; literature related to the study; conceptual considerations; data description and analytical procedures; and the findings. The last section of the chapter discusses what was considered to be the major limitations of the study.

6.1. Problem Statement and Study Objectives

The study investigated the impact of rising costs of production on wheat output in Zambia with a view of considering policy recommendations that will enable Zambia to attain her goal of self-sufficiency in wheat products. It was noted that, though wheat products do not constitute staple foods for the vast majority of Zambia's 8.02 million people, they nonetheless constitute a significant proportion in the diets of most people, more especially the urban consumers. In terms of agricultural activity, wheat is emerging as one of the dominant crops among large scale commercial farmers.

In recent years, production costs have been rising reflecting the high inflation rate in the economy. Given that there has been a rise in production costs, the study therefore endeavoured to determine the impact of such cost rises on wheat producers' behaviour, and hence output. It was believed that an understanding of producers' behaviour viz-á-viz changes in production costs would greatly benefit agricultural planners in developing and executing policies that would raise wheat output, and hence attainment of national self-sufficiency in wheat products.

The objectives of the study were therefore to determine the impact of rising variable production costs on producers' behaviour, and hence wheat output-supply; to determine the impact of variable factor prices on wheat output; to determine the impact of wheat price on wheat output; and to suggest policy recommendations to boost output. Based on these objectives, hypotheses were formulated and tested.

It was noted that wheat production in Zambia was a relatively new activity as compared to other major crops like maize, cotton, sunflowers and tobacco. Because of the high cost of production as noted by earlier studies, wheat is produced entirely by large scale commercial farmers.

Although current domestic production does not meet domestic consumption, government policy prohibited wheat imports as of 1988. This policy however seemed to have been fully implemented in 1990 when absolutely no imports were made. The object of the policy was to protect local producers from imports.

As an irrigated crop, wheat production has high potential in most parts of the country. But presently, production is concentrated in southern and central parts of the country where infrastructure favourable to its production is largely developed.

Up to 1985, government fixed and controlled wheat producer price. After that, the price was allowed to be determined by market forces though the government still set floor prices so as to ensure that farmers got a reasonable price.

6.2 Review of Literature

Perhaps because it is relatively a new crop, literature on the economics of wheat production in Zambia is very limited. Most studies on Zambian agriculture have been focusing on maize production.

One major study on wheat is that done by Kasalu (1987) in which efficiency of wheat production in Zambia was investigated using a cost-benefit analysis approach. The model farms analyzed were estate cooperation, irrigated commercial and rain-fed commercial production categories. Also examined were foreign exchange costs and economic viability of producing wheat locally as opposed to importing it. The study concluded that it was financially and economically feasible to grow wheat using estate cooperation category and that it also made efficient use of Zambia's limited national resources. The irrigated commercial category was financially profitable but it was not economically feasible and inefficiently used the country's resources. The rain-fed category was neither financially nor economically viable at the then yield levels.

This study differed from Kasalu's study in terms of analytical approaches adopted. While Kasalu used a cost-benefit analytical procedure, the current study utilized an econometric technique. The econometric technique facilitated the analysis of decision making behaviour of wheat producers.

Another study reviewed despite it not being conducted in Zambia is that by Sidhu and Baanante (1981). Sidhu and Baanante used farm-level data to estimate input demand and wheat supply in the Indian Punjab. Their study is similar to the current study in that both studies used disaggregated farm-level data to study farmer behaviour. Furthermore, to a large extent, the analytical techniques used in both studies are similar.

6.3 Conceptual Framework and Empirical Model

Production economics literature in microeconomic theory provided the framework within which this study was conducted. Because of data availability considerations, a dual rather than a primal approach was found to be more appropriate. Besides data considerations, the dual approach enabled us to conveniently analyze more problems while at the same time ensuring consistency in microeconomic and econometric underpinnings.

The empirical model was derived from the cost-function by assuming that the standard assumptions regarding producer behaviour in a competitive environment held. A translog cost-function was specified, and from it, conditional factor demands were derived by applying Shephard's lemma. Since factor demands are not linear in parameters, factor shares, which are linear in parameters, were derived from them.

Because of data limitations, only land was included as a quasi-fixed input. Other fixed inputs were not included. None inclusion of the other fixed inputs was not expected to cause bias in the econometric results as fixed inputs are generally viewed as predetermined.

As the cost-function ignores the effect of product price on output, an output-supply equation was specified and estimated. It was modelled as a function of normalized product and variable factor prices as well as wheat hectarage.

As has already been indicated, the variables included in the cost-function aspect of the model were prices for variable inputs, output levels and land as a quasi-fixed input.

The variable prices were for seed-wheat; basal and top dressing fertilizers; chemicals; fuel and labour. The dependent variables were expenditure shares of the respective variable inputs. In the output-supply aspect of the model, output was the dependent variable while normalized prices of wheat; seed-wheat; basal and top dressing fertilizers; chemicals; and labour as well as area planted under wheat were the explanatory variables. The prices were normalized by fuel price.

6.4.1 Data Collection and Description

The study used pooled cross-section and time series data. The data set pertained to thirty-six farmers over the period 1988 to 1991, and was collected through a survey that was conducted among wheat producers. The data that farmers provided pertained to input usage and expenditures on variable inputs; and wheat hectarage and output levels. No farmer reported using lime. They claimed that they limed the soil as they irrigated. Time series data on output prices; interest rate; exchange rate; inflation rate; and consumer price index were collected from the Ministry of Agriculture; Central Statistical Office; Commercial Farmers' Bureau; and the National Milling Company. Factor prices were also collected directly.

The sources of variations in prices of inputs were the various types of fertilizers and chemicals that each individual farmer used in the respective years, variation in some input prices due to geographic location of individual farmers and sources of supply for other inputs.

6.4.2 Analytical Procedure

To facilitate pooling of the cross-sectional and time series data sets, the data was organized and entered according to the decision units. There were thirty-six decision units studied over a four-year time period resulting in a sample size of 144. Since there were eight explanatory variables in each of the factor share equations, the number of observation points was 1152.

For estimation purposes, the factor share equations were developed into stochastic form by assuming that the observed input demands were distributed stochastically along the expansion path. Similarly, the output-supply equation was also developed into stochastic form.

Zellner's seemingly unrelated regressions were used to estimate the factor shares while the ordinary least squares estimation procedures were used to estimate the output-supply function.

6.4.3 Elasticity Calculations

This section, showed how elasticities of substitution and those of factor demands were calculated from the estimated parameters of factor share equations. As for the price elasticity of supply, the wheat price coefficient of the supply equation gave the elasticity value as well since the function was estimated in a double log-form.

6.4.4 Hypotheses Testing

The hypotheses tested were as follows.

Firstly, the hypothesis that farmers' behaviour did approximate cost minimization was tested.

Secondly, the hypothesis that variable factor prices, individually or jointly, had no significant influence on wheat output was tested.

Lastly, the hypothesis of statistical insignificance of wheat price on output was tested.

6.5 Empirical Results

6.5.1 Results of Factor Share Equations and Output Supply

The empirical results showed that, except for fuel for farm machinery, the increases in variable production costs have not led to reductions in factor usage. Neither have they adversely affected wheat output. This is because, output price seemed to have been sufficiently high to off-set the impact of rising variable factor prices. Wheat price has had a significant influence on output.

With regards to increases in hectarage viz-á-viz factor usage, we observed that as hectarage increased, seed-wheat and chemicals expenditure shares increased while expenditure shares of basal and top fertilizers and of labour declined proportionately.

Except for top-dressing fertilizers, own-price elasticities of substitution had the theoretically correct signs—they were negative. Labour was portrayed as a substitute for chemicals, fuel, basal and top fertilizers. The degree of substitutability was however much lower for basal fertilizers as compared to fuel, chemicals and top fertilizers. Labour portrayed a complimentary relationship to seed-wheat. Fuel and labour showed to be the most sensitive to own price changes.

Except for fuel whose own-price elasticity is close to unit, both own and cross-price elasticities of factor demands were much lower than absolute one indicating that variable factor price changes have little impact on variable factor demands.

As already indicated, wheat price has had a significant influence on output. Factor prices, either individually or jointly did not. Price elasticity of supply was 0.084 indicating that output was not responsive to output price changes. Direct and significant relationship was portrayed between output and hectarage. Also, output showed to be responsive to changes in hectarage.

6.5.2 Hypotheses Test Results

The symmetric restriction was not rejected at 1 percent significance level. Coupled with the linear homogeneity restriction which also was not rejected at 5 percent significance level, cost minimization test was considered satisfactory. That is, the results were considered satisfactory to conclude that producer behaviour did approximate cost-minimization. The hypothesis of statistical insignificance of wheat output price on output was rejected at 10 percent significance level. That of statistical insignificance of factor prices, either individually or jointly was not rejected even at 10 percent significance level.

6.5.3 Conclusions

From the findings, it was concluded that the rise in variable production costs during the period under study had no adverse effect on wheat output in Zambia. Wheat price had a positive impact on output. As such, government need not provide subsidies on variable inputs to increase output as long as output price was sufficiently high.

6.5.4 Recommendations

To boost wheat production so as to achieve the self-imposed goal of attaining national self-sufficiency in wheat products, it was recommended that: government need not provide subsidies on variable factor inputs as long as wheat price was sufficiently high; the current pricing policy should be continued; government policy should emphasize technological innovations and/ or adoption; and government should provide subsidies on fixed inputs and facilitate the provision of necessary infrastructure to encourage entry into the industry.

6.6 Limitations of the Study and Scope for Further Research

Perhaps the major limitation of the study is that, with the exception of land, the impact of fixed inputs on wheat output was not explicitly considered in the model. It would be interesting to note how increases in the cost of these inputs affect wheat producers' decision making behaviour. However, even without modelling the impact of fixed inputs on output, the results obtained provided us with valuable insights into the behaviour of wheat producers.

For further research, it is recommended that the focus be on the impact of fixed inputs on wheat output. This would greatly facilitate policy formulation regarding investments in the industry.

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APPENDIX A: WHEAT PRODUCTION IN ZAMBIA: ACREAGE RESPONSE EQUATIONS ESTIMATES, 1988-1991.

A: Wheat Production in Zambia: Acreage Response Equations Estimates, 1988-1991.

Variables	Estimated Coefficient	
Dependent Variable	Output/Hectarage	Hectarage
Normalized price of		
Wheat	0.084** (0.050)	0.131 (0.119)
Seed-Wheat	0.146 (0.234)	-1.156* (0.555)
Basal fertilizers	-0.146 (0.203)	-0.665 (0.485)
Chemicals	0.026 (0.041)	-0.082 (0.098)
Top fertilizers	0.017 (0.179)	0.506 (0.428)
Labour	0.105 (0.191)	1.049* (0.450)
Hectarage	0.030 (0.036)	—
Constant	2.846* (0.914)	7.589* (2.103)

Note:

- Standard errors are in parentheses.
- One asterisk indicates statistical significance at 5 percent significance level.
- Two asterisks indicate statistical significance at 10 percent significance level.

APPENDIX B: Number of Irrigated Wheat Growers, Area Planted and Production: 1986-1991

B: Number of Irrigated Wheat Growers, Area Planted and Production: 1986-1991

Year	No. of Growers	Area Planted†	Production‡
1986	72	6,380	329,968
1987	64	7,397	307,421
1988	71	8,742	412,483
1989	71	9,871	517,887
1990	70	11,585	595,570
1991	70	11,849	652,580

Note: † Area planted is measured in hectares.

‡ Production is measured in 90 kilogram bags.

Source: Ministry of Agriculture: Agricultural Statistics Bulletins.

APPENDIX C: Wheat Output Price, 1987-1991

C: Wheat Output Price Per 90 kilogram bag in Zambian kwacha (ZK).

Year	Government Floor Price	National Milling Company Price
1987	111.00	190.00
1988	190.00	336.68
1989	225.80	850.00
1990	487.00	1245.00
1991	683.90	2365.00

APPENDIX D: Farm Survey Questionnaire

D: Farm Survey Questionnaire

1. Size of the Farm ______________________ (Hectares)

2. Since when have you been growing wheat? ______________

3. For questions 3 (a) and 3 (b), we request you to give us data on the following for the period 1987 to 1991:

(a) Total wheat hectarage (ha.): 1987 __________ 1988 _________

1989 _____________ 1990 ________________ 1991 __________

(b) Total wheat output (in metric tonnes or 90 kg bags):

1987 ___________ 1988 _______________ 1989 _______________

1990 _______________ 1991 _________________

4. For questions 4 (a) to 4 (g), we would like you to give us data on total expenditures for the following inputs during the period 1987 to 1991.

(a) Total expenditures on seed-wheat: 1987_______ 1988 _______

1989 ______________ 1990 _____________ 1991 _____________

(b) Total expenditures on fertilizers:

(i) Basal dressing: 1987 _____________ 1988 ______________

1989 ______________ 1990 _____________ 1991 ____________

(ii) Top dressing: 1987 ________________ 1988 _______________

1989 _____________ 1990 ______________ 1991 ____________

(c) Total expenditures on lime: 1987 __________ 1988 ___________

1989 _____________ 1990 ______________ 1991 _______________

D: Farm Survey Questionnaire (Continued)

(d) Total expenditures on chemicals: 1987 ________________

1988 ____________________ 1989 ____________________

1990 ____________________ 1991 ____________________

(e) Total expenditure on fuel (diesel and petrol) directly used in wheat production:

1987 ________________ 1988 ________________

1989 ______________ 1990 ______________ 1991 ____________

(f) Total expenditures on labour: 1987 _________ 1988 ____________

1989 ______________ 1990 ______________ 1991 ____________

(g) Total expenditures on OTHER variable inputs (e.g electricity) for the same period: 1987 _________ 1988 ___________

1989 _____________ 1990 ________________ 1991 _______________

5. For questions 5 (a) to 5 (e), we would like you to give us data on the quantities that you used for the following inputs:

(a) Seed-wheat (in kilograms or tonnes): 1987 ______________

1988____________________ 1989 ____________________

1990 ____________________ 1991 ____________________

(b) (i) Basal dressing fertilizer: 1987 __________________

1988 ____________________ 1989 ____________________

1990 ____________________ 1991 ____________________

(ii) Top dressing fertilizer: 1987___________ 1988 _________

1989 _______________ 1990 ____________ 1991 ______________

D: Farm Survey Questionnaire (Continued)

(c) Lime (in kilograms): 1987________ 1988 ________

1989 ________ 1990 ________ 1991 ________

(d) Chemicals (in litres or kgs): 1987 ________

1988 ________ 1989 ________

1990 ________ 1991 ________

(e) Fuel (in litres): 1987 ________ 1988 ________

1989 ________ 1990 ________ 1991 ________

THANK YOU !!!

APPENDIX E: FARM DATA

(i). Farm Number, Hectarage and Output Levels

(ii). Farm Number and Variable Input Quantities Used

(iii). Farm Number and Variable Input Prices

E: (i). Farm Number, Hectarage and Output Levels

Farm Number	Hectarage	Output Levels[1]
1	102	5082
1	165	11589
1	200	14000
1	200	14444
2	200	12889
2	250	12500
2	250	13889
2	207	13400
3	20	1000
3	20	1111
3	25	1389
3	50	2500
4	52	1601
4	52	1652
4	55	1850
4	55	2150
5	75	1700
5	75	2200
5	75	2700
5	80	4000
6	60	2778
6	75	3856
6	80	3889
6	65	3000
7	25	1389
7	30	2000
7	30	2000
7	25	1667
8	120	7200
8	120	7200
8	120	7200
8	120	9000
9	100	6500
9	120	7200
9	120	8400
9	120	7200
10	100	2000
10	130	2200
10	140	2600
10	140	3500
11	120	2282
11	120	4000
11	120	5820
11	130	7402
12	30	1350
12	30	1000
12	30	1300
12	30	1200
13	240	11111
13	240	13333
13	220	13333
13	141	10222

E: (i). Farm Number, Hectarage and Output Levels (continued)

Farm Number	Hectarage	Output Levels
14	1500	24000
14	1500	25000
14	1500	34000
14	1600	35000
15	180	9400
15	230	14311
15	230	14822
15	230	14822
16	130	7500
16	130	7500
16	130	7600
16	130	7600
17	140	6700
17	140	4500
17	140	6800
17	120	6000
18	120	6500
18	150	7000
18	150	7500
18	170	8800
19	14	600
19	6	300
19	14	280
19	20	1000
20	25	398
20	15	258
20	13	224
20	10	172
21	20	778
21	20	900
21	10	500
21	4	200
22	100	5800
22	120	7000
22	120	7000
22	120	6800
23	200	14444
23	200	13333
23	150	7000
23	200	14444
24	230	15870
24	200	14000
24	200	14000
24	200	14400
25	70	1944
25	80	2222
25	80	2222
25	70	1944
26	120	10667
26	120	11733
26	130	11556
26	130	13722

E: (i). Farm Number, Hectarage and Output Levels (continued)

Farm Number	Hectarage	Output Levels
27	700	45422
27	700	49000
27	719	52727
27	722	53056
28	60	2667
28	80	3500
28	120	6500
28	130	10000
29	80	2222
29	120	3333
29	120	4000
29	120	4667
30	8	990
30	12	1000
30	30	1000
30	25	950
31	80	3556
31	90	4500
31	90	3960
31	60	3300
32	20	1444
32	30	2000
32	30	2000
32	40	2667
33	50	2500
33	80	5333
33	100	7000
33	100	7244
34	30	1000
34	40	976
34	64	2432
34	64	2460
35	70	2722
35	70	3033
35	90	3900
35	100	5500
36	110	8556
36	120	9233
36	108	9233
36	105	8400

¶ Output level is measured in 90 kilogram bags

E: (ii) Variable Input Quantities Used§

Farm Number	Seed-wheat	Basal-fert'zers	Top-fert'zers	Chemicals	Fuel	Labour
1	226	1128	663	203	1890	1840
1	513	1984	661	348	3135	3300
1	640	2200	800	400	4200	4000
1	720	2000	1000	422	4000	4009
2	520	1400	1400	230	24000	12380
2	500	1750	1750	300	30000	16250
2	600	1500	1500	250	25000	16250
2	500	1240	1240	200	21000	13455
3	48	150	75	40	2000	400
3	48	150	75	50	1600	450
3	60	188	94	62	1500	500
3	120	375	188	125	2250	1000
4	130	390	200	40	560	3640
4	132	392	200	50	570	3120
4	148	400	250	45	600	3025
4	148	450	250	50	600	3310
5	300	320	225	250	900	5250
5	300	320	225	250	900	4500
5	300	350	225	250	900	3375
5	320	400	240	270	1200	3200
6	120	480	300	120	120	3600
6	150	600	375	150	150	3000
6	192	640	400	160	160	4000
6	182	520	325	130	130	2925
7	90	312	50	38	2500	500
7	108	375	60	45	2700	600
7	108	360	60	45	2100	675
7	90	369	50	38	1500	625
8	312	1800	720	300	12000	2400
8	312	1800	720	300	10800	2600
8	432	1800	720	300	7200	2800
8	432	1800	720	300	5400	2700
9	200	1200	1000	250	12000	2000
9	240	1440	1200	300	12000	2400
9	240	1440	1200	300	9600	2475
9	240	1440	1200	300	7200	2530
10	200	500	250	250	8000	2190
10	260	650	324	325	9000	2600
10	280	700	350	350	10500	2800
10	310	700	350	350	10500	3110
11	147	960	600	360	13200	1007
11	602	960	600	360	12000	2050
11	860	960	600	360	9600	2518
11	335	1040	650	390	7800	3415
12	60	360	150	45	6147	6400
12	60	360	150	45	3676	7385
12	60	360	150	45	2669	8535
12	60	360	150	45	1300	4240
13	720	2880	1440	600	14400	4800
13	720	2880	1440	600	12000	5100

E: (ii) Variable Input Quantities Used (continued)

Farm Number	Seed-wheat	Basal-fert'zers	Top-fert'zers	Chemicals	Fuel	Labour
13	660	2640	1320	550	9900	4400
13	505	1692	652	303	6345	2820
14	2700	4000	2700	731	65265	4235
14	2700	4000	2700	731	65625	4350
14	2700	4000	2700	731	65625	5000
14	2700	4200	2700	780	70000	4516
15	468	2160	950	360	19800	3600
15	598	2300	920	460	20700	4600
15	644	2070	920	460	16100	4850
15	644	1840	920	460	10350	6550
16	260	1560	1300	182	14300	2600
16	260	1560	1300	182	13000	3010
16	260	1560	1300	182	13000	2890
16	260	1560	1300	182	13000	3100
17	252	1400	1400	210	21000	2800
17	308	1260	1260	210	16800	3000
17	336	1260	1260	210	14000	2950
17	288	1080	1080	180	9600	2400
18	300	1200	500	550	20000	2500
18	360	1440	600	600	25000	2885
18	440	1800	600	600	30000	3000
18	500	2040	700	700	30000	1700
19	31	126	84	28	1400	1662
19	30	54	36	12	540	712
19	31	126	84	28	1120	1780
19	60	180	120	40	1600	2375
20	77	244	175	30	2250	500
20	106	157	212	25	1350	300
20	138	127	18	25	650	260
20	60	100	70	15	450	200
21	44	200	200	50	2000	400
21	52	200	200	50	1600	455
21	26	100	100	25	500	200
21	10	40	40	10	200	100
22	260	1500	750	160	4500	2000
22	312	1800	900	192	5400	2400
22	312	1800	900	192	5400	2600
22	312	1800	900	192	5400	2750
23	800	2500	1750	300	14000	4000
23	800	2500	1750	300	14000	4510
23	600	1875	1312	225	10500	3462
23	800	2500	1750	300	14000	4315
24	552	2760	1380	345	36800	6900
24	480	2400	1200	300	22518	4616
24	480	2400	1200	300	13400	10345
24	480	2400	1200	300	6000	5940
25	120	630	154	175	8400	1400
25	160	720	176	200	8000	1600
25	160	720	176	200	7200	1700
25	126	630	154	175	5600	1530

E: (iii) Variable Input Prices (in Zambian Kwacha)

Farm Number	Seed-wheat	Basal-fert'zers	Top-fert'zers	Chemicals	Fuel	Labour
1	188.00	65.00	55.00	265.00	2.668	20.00
1	203.00	85.75	70.00	301.25	3.566	30.00
1	394.00	300.00	360.00	390.00	5.135	45.00
1	1300.00	490.00	400.00	505.32	25.100	80.00
2	188.00	73.00	55.10	181.00	2.668	20.00
2	203.00	95.00	60.00	185.95	3.566	30.00
2	394.00	370.00	340.00	240.69	5.135	45.00
2	1300.00	530.00	424.95	375.00	25.100	80.00
3	195.25	75.15	57.00	45.00	2.961	8.00
3	210.00	92.00	62.15	69.00	4.122	20.50
3	390.49	396.00	300.00	158.99	6.015	33.00
3	1350.00	515.00	435.70	193.50	27.111	48.00
4	188.00	73.00	55.10	265.00	2.668	20.00
4	203.00	95.00	60.00	301.25	3.566	30.00
4	394.00	370.00	340.00	390.00	5.135	45.00
4	1300.00	530.00	424.95	505.32	25.100	80.00
5	195.25	72.45	60.00	45.00	2.961	8.00
5	210.00	115.00	72.00	69.00	4.122	20.50
5	390.49	330.75	362.00	158.99	6.015	33.00
5	1350.00	500.00	410.00	193.50	27.111	48.00
6	195.25	72.45	57.00	29.17	2.961	8.00
6	210.00	115.00	62.15	69.00	4.122	20.50
6	390.49	330.75	300.00	158.99	6.015	33.00
6	1350.00	500.00	435.70	193.50	27.111	48.00
7	203.00	83.00	57.60	270.00	2.553	16.00
7	320.00	120.19	90.30	325.00	3.885	28.00
7	380.00	363.00	370.00	509.95	7.112	39.00
7	1500.30	500.00	434.90	402.00	28.000	75.00
8	230.00	79.50	63.40	47.00	3.011	9.50
8	223.00	130.00	77.50	71.00	5.100	22.50
8	445.00	375.00	355.00	157.00	8.333	32.00
8	1385.00	505.00	433.00	186.00	30.000	46.00
9	203.00	71.15	57.60	16.00	2.553	16.00
9	320.00	97.60	90.30	63.35	3.885	28.00
9	380.00	344.00	370.00	179.30	7.112	39.00
9	1500.00	520.00	434.90	184.00	28.000	75.00
10	220.00	83.00	60.00	17.50	2.553	16.00
10	320.00	120.19	77.00	76.00	3.885	28.00
10	380.00	363.00	370.00	157.90	7.112	39.00
10	1500.30	500.00	440.00	198.00	28.000	75.00
11	230.00	79.50	63.40	280.60	3.011	9.50
11	223.00	130.40	77.50	342.00	5.100	22.50
11	445.00	375.00	355.00	407.12	8.333	32.00
11	1385.00	540.00	433.00	525.75	30.000	46.00
12	230.00	80.12	50.95	280.60	3.011	9.50
12	223.00	89.10	80.00	342.00	5.100	22.50
12	445.00	368.00	375.00	407.12	8.333	32.00
12	1385.00	505.00	439.00	525.75	30.000	46.00
13	212.00	77.50	64.00	20.00	2.802	15.00
13	297.20	99.00	86.30	68.00	3.721	26.00

E: (ii) Variable Input Quantities Used (continued)

Farm Number	Seed-wheat	Basal-fert'zers	Top-fert'zers	Chemicals	Fuel	Labour
26	288	1320	600	90	14400	2400
26	288	1320	600	90	12000	2650
26	312	1430	650	100	11700	2600
26	312	1430	650	100	10400	2700
27	2196	8400	3500	2800	497930	37246
27	2201	8400	3500	2800	325746	24373
27	2253	8628	3595	2876	250032	45660
27	2236	8668	3612	2890	96650	53017
28	132	840	360	120	9000	1200
28	192	1200	500	200	9600	1231
28	288	1800	800	300	14400	882
28	300	2000	1000	325	13000	1103
29	160	1040	240	240	8000	640
29	312	1560	360	360	12000	1847
29	288	1560	360	360	6000	2080
29	240	1560	360	360	3600	1018
30	14	80	24	12	640	160
30	22	100	36	18	720	240
30	54	240	90	45	1800	600
30	45	240	120	38	1125	500
31	240	640	320	320	11600	269
31	288	720	270	360	13500	552
31	288	720	270	260	12600	540
31	192	480	180	240	8400	208
32	48	80	100	60	2800	800
32	72	120	150	90	3600	1050
32	72	120	150	90	3600	900
32	96	160	200	120	1800	800
33	90	600	350	100	37500	1000
33	160	960	560	160	60000	1600
33	220	1200	700	200	75000	2000
33	250	1200	650	200	72000	2315
34	78	360	150	90	3000	600
34	104	480	200	120	4000	800
34	166	768	320	192	6400	1280
34	166	768	320	192	6400	1330
35	168	630	350	210	8400	1400
35	140	560	350	210	7000	1670
35	180	720	450	300	10000	1800
35	300	800	500	300	10000	2000
36	198	1320	550	154	13200	880
36	216	1440	600	168	12000	740
36	259	1296	540	151	7776	749
36	252	1260	525	147	3150	355

§ Seed-wheat, basal and top dressing fertilizers are measured in 50 kilogram bags; chemicals and fuel are measured in liters; and labour is measured in man-days.

E: (iii) Variable Input Prices (in Zambian Kwacha) continued.

Farm Number	Seed-wheat	Basal-fert'zers	Top-fert'zers	Chemicals	Fuel	Labour
13	415.00	385.00	358.90	173.00	5.335	38.00
13	1600.00	535.00	447.00	188.00	27.231	70.00
14	250.00	88.75	62.90	43.05	3.501	8.50
14	301.00	92.50	75.00	83.00	5.000	21.00
14	430.10	380.00	368.00	161.00	6.724	37.70
14	1670.10	567.00	415.00	190.00	28.451	52.00
15	250.00	79.00	51.90	290.17	3.501	8.50
15	301.00	95.50	88.00	310.00	5.000	21.00
15	430.35	350.15	380.00	392.00	6.724	37.40
15	1670.10	540.15	400.00	520.00	28.451	52.00
16	212.00	77.50	50.55	268.20	2.802	15.00
16	297.20	99.00	65.00	315.00	3.721	26.00
16	415.00	385.00	360.00	411.50	5.335	38.00
16	1600.00	535.00	430.00	515.00	27.231	70.00
17	228.00	66.95	54.15	290.00	3.000	9.00
17	242.99	112.50	77.00	344.25	4.856	23.25
17	460.00	305.00	383.00	530.00	7.750	46.00
17	1630.00	530.00	427.00	410.00	29.533	57.00
18	212.00	83.00	64.00	268.20	2.802	15.00
18	297.20	97.60	86.30	315.00	3.721	26.00
18	415.00	312.00	358.90	411.50	5.335	38.00
18	1600.00	515.00	447.00	515.00	27.231	70.00
19	228.00	84.13	67.00	300.00	3.000	9.00
19	242.99	101.00	85.25	344.25	4.856	23.25
19	460.00	390.00	384.00	410.00	7.750	46.00
19	1630.00	550.00	445.00	530.00	29.533	57.00
20	220.00	80.00	55.00	181.00	2.779	12.50
20	285.00	97.00	70.00	185.95	5.440	29.00
20	450.00	399.50	320.25	240.69	9.961	35.00
20	1390.00	503.00	450.00	375.00	29.000	65.00
21	228.00	84.13	67.00	33.20	3.000	9.00
21	242.99	101.00	85.25	88.50	4.856	23.25
21	460.00	390.00	384.00	175.00	7.750	46.00
21	1630.00	550.00	445.00	210.00	29.533	57.00
22	220.00	80.00	55.00	277.00	2.779	12.50
22	285.00	97.00	70.00	340.40	5.440	29.00
22	450.00	399.50	320.25	397.50	9.961	35.00
22	285.00	503.00	450.00	541.35	29.000	65.00
23	250.00	79.00	62.90	43.05	3.501	8.50
23	301.00	88.00	75.00	83.00	5.000	21.00
23	430.10	350.30	368.00	161.00	6.724	37.40
23	1670.10	540.15	415.00	190.00	28.451	52.00
24	220.00	75.00	55.00	40.00	2.779	12.50
24	285.00	100.05	70.00	84.00	5.440	29.00
24	450.00	370.00	320.25	160.00	9.691	35.00
24	1390.00	512.00	450.00	189.00	29.000	65.00
25	207.15	89.00	58.00	35.10	3.225	8.75
25	273.12	110.00	90.00	77.35	4.910	25.00
25	370.90	395.00	310.15	156.00	7.375	40.00
25	1679.80	508.00	411.00	198.00	30.874	50.00

E: (iii) Variable Input Prices (in Zambian Kwacha) continued.

Farm Number	Seed-wheat	Basal-fert'zers	Top-fert'zers	Chemicals	Fuel	Labour
26	207.15	85.00	62.00	288.00	3.225	8.75
26	273.12	107.60	100.00	312.00	4.910	25.00
26	370.90	360.30	366.50	405.00	7.375	40.00
26	1679.80	492.00	430.00	510.00	30.874	50.00
27	210.50	66.00	63.00	24.00	3.302	10.00
27	237.20	90.50	80.50	66.00	4.716	24.00
27	468.00	374.00	375.00	179.30	5.450	42.00
27	1450.00	528.00	428.00	197.00	25.901	53.00
28	207.15	89.00	58.00	35.10	3.225	8.75
28	273.12	110.00	90.00	77.35	4.910	25.00
28	370.50	395.00	310.15	156.00	7.375	40.00
28	1679.80	508.00	411.00	198.00	30.874	50.00
29	222.00	82.30	52.30	32.00	3.566	9.75
29	305.00	94.00	75.30	64.05	5.120	21.75
29	375.00	379.00	315.00	165.00	8.507	32.50
29	1413.00	520.00	445.16	185.15	26.551	56.00
30	215.75	74.22	56.00	42.30	2.721	14.00
30	310.00	93.25	85.00	70.00	4.425	27.00
30	400.00	363.00	330.45	163.50	5.775	36.00
30	1395.25	505.00	420.00	193.00	25.445	60.00
31	215.75	74.22	56.00	30.16	2.721	14.00
31	310.00	93.25	88.00	75.00	4.425	27.00
31	400.00	363.00	350.13	163.50	5.775	36.00
31	1395.25	505.00	424.00	193.00	25.445	60.00
32	222.00	82.30	52.30	32.00	3.566	9.75
32	305.00	94.00	75.30	64.04	5.120	21.75
32	375.00	379.00	315.00	165.00	8.507	32.50
32	1413.00	520.00	445.16	185.15	26.551	56.00
33	215.75	68.75	56.00	285.00	2.721	14.00
33	310.00	95.40	85.00	322.00	4.425	27.00
33	400.00	325.05	330.45	399.00	5.775	36.00
33	1395.25	498.99	420.00	537.23	25.441	60.00
34	222.00	65.50	52.30	187.50	3.566	9.75
34	305.00	86.30	75.30	190.60	5.120	21.45
34	375.00	97.30	315.00	283.30	8.507	32.50
34	1413.00	544.00	445.16	400.00	26.551	56.00
35	210.50	66.00	59.10	273.50	3.302	10.00
35	237.20	89.95	87.00	320.00	4.716	24.00
35	468.00	374.00	350.00	412.55	5.450	42.00
35	1450.00	528.00	409.95	512.00	25.901	53.00
36	235.00	90.00	63.00	273.50	3.302	12.00
36	227.00	115.00	80.50	328.75	6.000	18.00
36	470.00	368.00	375.00	412.55	5.450	46.00
36	1500.00	560.00	428.00	530.00	27.000	60.95