PRODUCTION UNDER RISK AND UNCERTAINTY: SMALL SCALE COTTON PRODUCTION IN ZAMBIA, 1985-1990

by

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To my parents, Mr and Mrs. Josam Jacob Mwiinga

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ABSTRACT

This study examines the role of risk and uncertainty in small scale agriculture in Zambia. Farmer's risk preferences are reviewed, and on the basis of these results, government agricultural policy towards small scale farmers is analyzed. Small scale farmers whose main crop is cotton are the target group because cotton is the major source of income in the outlying areas of Zambia. The study also reviews the structure of the cotton sector in the country and the constraints on its development. A two crop output model is used in the analysis. Maize has been selected as the second crop because it is the most common crop among small scale farmers in the country.

Production levels for the two crops are used in the analysis for the period between 1985 and 1990. Farm level data were collected from a total of thirty farmers in the two of the three main cotton producing areas. Average rainfall data were acquired from the agricultural office in each region. In addition, the impact of technology change was incorporated in the risk and uncertainty model.

Various hypotheses are tested. The results show that small scale farmers have probably reduced the amount of input usage in their production process. This could be as a result of the high input prices and lack of financial capital to purchase the inputs required. The results also show that the small scale farmers are not risk neutral. Further testing showed that these farmers are risk averse. Consequently, the low average productivity exhibited over the years is a result of other factors. The variance of weather is one of these factors that has affected farmer decisions.

A test to determine how farmers respond to technical change is also done. The

test for Hicks neutral is rejected, implying that because of technical change there has been variable input substitutions during the period. These technical changes could include the use of hybrid seed and other chemical inputs. If the model results suggest that farmers are risk averse and have used high yielding varieties of seed and other inputs, then the low average productivity of cotton is the result of other factors.

The study further suggests that government policy in output pricing mechanism; production incentives; extension and research; and credit availability are the factors that have resulted in low average productivity of cotton. Therefore, these policies, the study suggests, be changed in such a way that small scale farmers benefit from such policies.

Based on the findings, this study indicates that farmers are rational and risk averse. Therefore, to ensure high average cotton production, the government should consider ways of increasing budgetary allocations for small scale agriculture. The government should also examine alternatives that could overcome the problem of collateral for small farmers. One method is to introduce legislation that would enable the farmers to have title deeds to their land. Privately- owned land could be used as collateral to borrow for capital inputs and increase their productivity. This would require careful analysis of the social/ cultural implications.

CHAPTER 1

INTRODUCTION

Cotton production in Zambia has been the main source of income for small scale farmers who produce at least 90 percent of the crop. Although the number of these farmers has been increasing over time, the average yield has been decreasing.

Programs to improve the productivity of Zambian cotton farmers have been introduced. Under the Lint Company of Zambia (LINTCO), programs have been designed to increase the provision of credit; to ensure the adequate and timely supply of inputs; to expand storage facilities and to diversify the market for the cotton crop. A few years after these programs were introduced, cotton production in the country seemed to have increased and slow shift towards cash crop production was observed. However, average yields of cotton per hectare, continued to decline.

A number of reasons have been given to explain the declining yields of the small farmers. First, farming practices have been below optimal standards. Most small scale farmers do not apply any fertilisers and rarely use the recommended amount of insecticides or herbicides on their cotton crop.

Government policy has not been favourable to small scale cotton farmers. In fact most agricultural policies have been to the advantage of the large commercial farmers. The imbalance in treatment is a result of the government's conception that small scale farmers are inefficient and hence a high risk group, though they contribute the majority of agricultural production.

A policy environment that treats small farmers equally is important because of the size of the subsector in Zambian agriculture and the need to increase overall production. The perception of government policy makers of small scale farmer's risk preferences is a major institutional impediment. Therefore it is important to empirically determine whether the current views of the government and lending institutions are justified.

1.1 Problem Statement

Cotton production, or generally agriculture in Zambia, is an uncertain activity because of the erratic weather conditions; lack of adequate credit facilities and other related conditions. Furthermore, government policy has not been supportive in ensuring that small scale farmers have a fair share of government incentives. This has lead to low levels of output shown by the decreasing average yields per hectare.

Adequate credit has not been available to small scale farmers. These farmers have been denied credit by commercial banks because they lack collateral. Land, which is their main possession, is state owned and cannot be used as collateral for credit purposes.

The major reason for the lack of a good policy framework for small scale farmers is that these farmers are considered to be insensitive to risk and therefore inefficient. This is a non-tested assumption. The test for this assumption involves the assessment of risk attitudes among these farmers given factors that affect variances of output. The problem solution will determine whether small scale farmers under conditions of uncertainty behave as risk-averse entrepreneurs.

1.2 Objectives of the Study

The overall objective of the study is to analyze small scale cotton production under conditions of risk and uncertainty. The specific objectives are:

i) to analyze the cotton subsector in Zambia

ii) to test risk preferences among small scale farmers;

iii) given risk, to evaluate various hypotheses about the importance of some variables in the model;

iv) to test for technical change, given risk.

1.3 Organization of the thesis

The thesis is divided into six chapters. Chapter 1 is a general overview of the problem statement and the research problem and identifies the main objectives of the study.

Chapter 2 describes the background, role and structure of the agricultural sector in Zambia. The structure and development of the cotton subsector, and production and marketing of cotton are also discussed. The Chapter also reviews the credit aspects in the agricultural sector. Due to the importance of land ownership in financing agricultural production, the land tenure system is examined.

Chapter 3 is the summary of the literature reviewed on the subject and Chapter 4 describes the data collected and used in the analysis. The Chapter also offers a descriptive analysis of farmer responses concerning cotton production in the sector.

Chapter 5 forms the theoretical framework of the model. The empirical model applied in the analysis is described in this chapter. The Chapter also provides the results of the econometric analysis and hypothesies testing. Finally the chapter provides the summary of the results obtained.

Finally, Chapter 6 contains a summary, and conclusions resulting from the study. It also provides some limitations of the study and recommendations on policy changes and further research.

CHAPTER 2

BACKGROUND INFORMATION

2.1 The Structure and Role of Agriculture

Agriculture in Zambia falls into four main categories (Table 2.1). First, there is the small scale farmer category. These farmers account for approximately 75 percent of the estimated 600,000 farm households, each cultivating an average of 2 to 5 hectares using family labour and simple hand tools. Small scale farmers produce primarily for subsistence and occasional marketable surpluses (maize), but contribute about 90 percent of cotton. They could produce more cotton, but the lack of adequate cash inflows and appropriate technical packages have limited their use of purchased inputs.

Second, there are approximately 130,000 small-scale commercial farmers (popularly known as emergent farmers) who account for 21 percent of the farm households and produce for both consumption and sale. On average, they cultivate approximately 10-15 hectares using oxen ploughs, improved seeds and fertilizers. Most of these farmers are situated along the rail line and the Eastern province where they have easy access to the transportation network of the country.

Medium scale farmers make up the third category. These are the farmers who are in the process of becoming small commercial farmers. They cultivate between 15-20 hectares of land and account for 26,000 farmers in the country.

Fourth, there are large-scale farmers. They constitute about 4 per cent of the farm households and cultivate an average of over 60 hectares each. These farmers use tractors and are highly mechanised. They account for 10 per cent of the cotton produced in the country. Table 2.1 below gives a breakdown of farmer categories in Zambia:

Table I: Estimation of number of farm units per Province

PROVINCE	**Large-Scale (above 60ha)**	**Medium-Scale (20-60ha)**	**Emergent (10-20ha)**	**Small-Scale (1-10ha)**
SOUTHERN	330	9,000	51,000	6,000
CENTRAL	300	7,500	21,000	18,000
C/BELT	n/a	500	2,000	18,000
LUSAKA	90	2,000	4,500	14,000
EASTERN	20	6,000	23,000	8,000
WESTERN	n/a	10	5,400	85,000
N/WESTERN	n/a	70	2,900	53,000
LUAPULA	n/a	60	2,000	73,000
NORTHERN	n/a	90	7,400	112,000
ZAMBIA	740	25,220	119,200	459,000

SOURCE: Ministry of Agriculture, 1989, Lusaka, Zambia.

Commercial agriculture in Zambia is concentrated along the rail lines and also in Eastern Province. It has been a major source of agricultural growth. Its contributions to output increased from 19 to 55 percent between 1965 and 1988. In contrast the real rate output increased from 19 to 55 percent between 1965 and 1988. In contrast the real rate of growth in the traditional sector has been stagnant and its relative share has declined significantly (World Bank, 1992).

Although Zambia has different ecological and climatic conditions, a number of agricultural commodities can be grown. However, it is the variability of climatic conditions in terms of the amount of rainfall that makes agriculture in these regions such an uncertain and a risky business venture. Erratic rainfall amounts and variations make agricultural decisions difficult especially among small scale farmers and hence place them in a high risk group.

The agricultural sector has an important role in the overall economy. The Zambian agricultural sector can be grouped into five subsectors: crops, livestock, fisheries, forestry and wildlife. Since independence, the policies of the government favoured improving production levels in the mining sector, but over the last few years, the policies have emphazed agricultural development. Between 1984 and 1986, the agricultural sector's contribution to the GDP increased from 332.2 million Zambian Kwacha to 363.8 million ZK in constant 1977 prices showing a percentage increment of 9.5 percent. Aggregate real agricultural growth averaged 2.4 percent a year between 1965 and 1982 compared to 7 percent during 1983-1988 (World Bank Report, 1992).

Small scale agriculture in Zambia has remained an important agricultural sector in the economy. During the period 1965 and 1982, large scale agricultural production contributed between 19 and 41 percent of overall agricultural production, while during the same period, small scale agriculture contributed between 59 and 81 percent of total GDP in the agricultural sector (World Bank, 1990). Between 1983 and 1988 large scale agriculture contributed between 41 and 49 percent and small scale agriculture contributed between 51 and 59 percent of total GDP in the agricultural sector (World Bank, 1990).

2.2 Objectives and performance of the Agricultural sector.

To promote agricultural production, the government stated long term objectives and goals. These objectives provide the policy guidelines to action programmes. These objectives also assist in providing a basis for determining the relative contribution of the agricultural sector to overall growth of the economy.

The government's stated long term objectives in the agricultural sector are:

i) equitable distribution of income and employment;

ii) national food security;

iii) increased production of import replacing commodities in which the country has comparative advantage;

iv) diversification in agriculture to broaden the export base of the economy; and

v) support education and training to improve the human resource base in the agricultural sector.

The agricultural sector has experienced slow increases and in some years declines in production. Growth in agricultural output averaged 1.8 percent per annum during 1974-1979 and only one percent during 1979-1983. During the same period, there was an increase in production in the traditional sector due to favourable weather conditions.

Table II: Percentage of GDP by Sector of Origin, 1965-1988

(Current prices)

	1965	1970	1975	1980	1985	1988
Agric,Fisheries	14	11	13	16	13	14
Mining,Quarry	41	36	14	14	16	15
Manufacturing	7	10	16	18	23	25
Construction 6	8	12	5	4	3	
Services	32	35	45	47	44	43

SOURCE: Central Statistical Office, Monthly Bulletins, Lusaka Zambia.

The table above shows the contribution of the agricultural sector to the overall GDP in relation to other sectors. The agricultural sector has remained as a low contributor to the overall GDP.

The relatively small share of GDP by the agricultural sector has masked the extent to which Zambians depend on the sector. Though a certain amount of subsistence agriculture is not reported in the GDP, it is not substantial enough to change the presented contribution. Overall, agriculture in Zambia has an outstanding growth rate, for instance in 1988 a growth rate of 20 percent recorded was as a result of a combination of substantial improvements in prices and good weather conditions. On average, the sector's real growth rate was 7.2 per cent between 1984 and 1988, compared to 2.4 per cent over 1965-1982 (World Bank, 1992).

Although individual crops(including exports) experienced better annual growth rates between 1984 and 1988 than during 1965-1983, their total production did not sustain an upward trend, indicating the possibility of crop substitution at the farm level as well as lack of incentives. More than 70 percent of viable agricultural land is not utilised, as such, the agricultural sector still remains the most viable sector that would sustain development in the country. In addition, it has a low dependence on imported inputs and comparatively low capital intensity, especially among small scale farmers, and a large potential for import substitution and increased exports.

2.3 Structure of the Cotton subsector in Zambia

Cotton was introduced into Zambia in the late 1950's. It remained a relatively minor crop with annual production of seed cotton varying between 2, 000 tonnes and 12,000 tonnes until the late 1970's (Table 2.6).

Prior to 1978, the Ministry of Rural Development in conjunction with the National Marketing Board encouraged cotton production in Zambia. In 1978, the Lint Company of Zambia was formed to spearhead cotton production among small scale farmers in the country through the provision of inputs; extension services; and a market for cotton.

The company's objectives were:

i) to achieve self sufficiency in cotton and eliminate cotton importation;

ii) to achieve an exportable surplus of lint;

iii) to improve the standards of cotton producers to be able to produce high grade cotton for export by providing extension services.

Lintco undertakes extension services, input supply, credit provision and other marketing related activities. A few years after the company was established, cotton production among small scale farmers had increased in nominal terms.

Cotton production has expanded from 15,000 tonnes of seed cotton in 1978/79 to 62,000 tonnes grown on 90,000 hectares by about 75,000 small scale farmers in 1990/91. Southern, Eastern and Central provinces are the main producing areas and produce about 96 percent of the crop. In these three provinces collectively, about 2,500 hectares of cotton is grown by privately owned companies who are largely capital intensive. Cotton is now predominantly a small scale farmer crop and this has improved rural conditions in terms of employment and income generation. Table III below shows the quantity of cotton produced between 1970-1991.

Table III: Production of Seed Cotton, 1970-1991.

Year	Prod.(kg)	Area(ha)	Av.yield (kg/ha)	No.of Growers	Av.area per grower (ha)
1970/71	11,823,367	13,388	883	7,225	1.85
1971/72	8,139,867	12,038	676	5,105	3.36
1972/73	5,160,497	8,662	596	3,849	2.25
1973/74	2,487,213	10,595	235	4,389	2.41
1974/75	2,599,874	8,040	323	4,201	1.91
1975/76	3,967,594	6,453	615	5,723	1.13
1976/77	8,928,831	10,509	850	10,152	1.04
1977/78	8,063,989	21,440	376	16,200	1.32
1978/79	14,979,228	21,454	698	22,937	1.33
1979/80	23,824,876	39,058	610	21,215	1.70
1980/81	16,927,899	38,395	441	15,721	1.81
1981/82	13,159,392	25,183	523	23,253	1.60
1982/83	32,085,102	34,237	937	23,253	1.47
1983/84	43,943,894	55,868	787	38,412	1.45
1984/85	30,274,998	54,758	553	38,421	1.43
1985/86	32,953,223	49,215	670	37,526	1.31
1986/87	27,730,690	38,158	727	32,236	1.18
1987/88	58,529,770	77,949	820	77,949	1.00
1988/89	33,545,379	90,717	370	67,964	1.33
1989/90	25,073,917	64,036	389	54,492	1.18
1990/91	55,939,776	91,987	610	76,644	1.20

SOURCE: Ministry of Agriculture and Lintco Annual Reports.

Several factors have led to the increase in cotton production. These include: an increase in area under cotton production; an increase in the number of cotton growers; and the effectiveness of the marketing system, especially the rapid payment system and the introduction of a cotton interest free credit scheme (Shawa, 1990).

Although the figures indicate massive crop production increases over the years, there have been variations in cotton production, but the average yield trend has been declining. These variations can be explained by the following:

i) more attractive returns from other crops, such as maize and groundnuts;

ii) cotton is a labour intensive crop especially during harvesting, among commercial farmers who do not use harvesting machinery;

iii) marketing arrangements prior to 1978 were not favourable.

The increase that is depicted is mainly a result of expansion in areas under cotton production. Average yields have been low, seldom exceeding 700 kilograms of seed cotton per hectare. This phenomenon has been as a result of the following:

i) the agricultural practices employed: most small scale farmers do not use recommended application rates of insecticides, herbicides and fertilisers;

ii) late delivery of inputs coupled with high costs have resulted in sub-optimal applications, hence reducing the effectiveness of pest control and yield potential.

iii) lack of adequate credit supply has rendered the farmers incapable of purchasing the required amount of inputs.

The increase in the number of small scale farmers and cotton production can be accredited to the diversity of the cotton subsector structure. Figure 1 shows the structure of the sector:

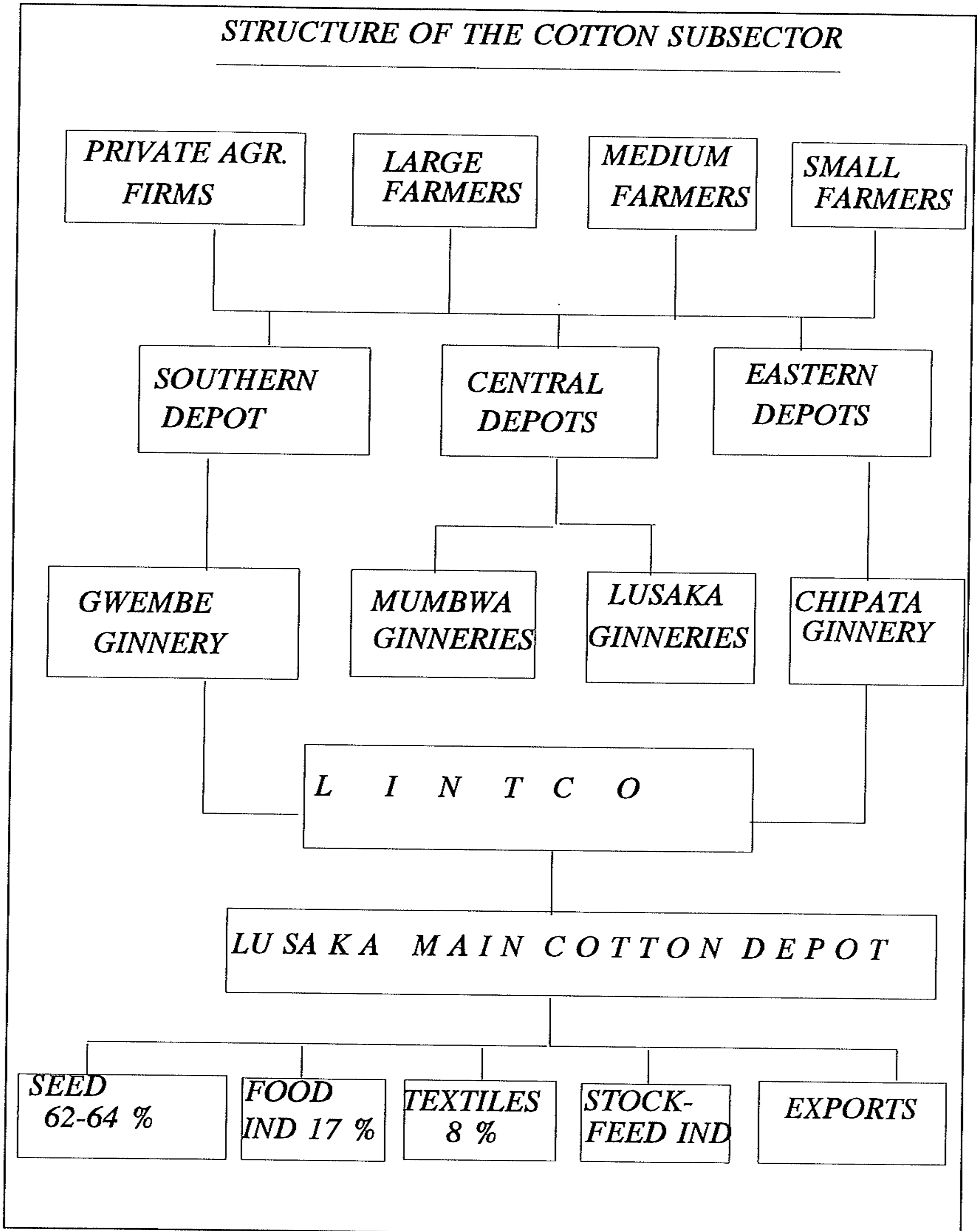

Figure 1: Structure of The Cotton Subsector in Zambia

The cotton subsector in Zambia can be divided into three major sections. The first section is made up of the direct production units. These are the small scale farmers, the medium scale farmers, the large scale farmers and finally privately owned agricultural firms. Small scale farmers contribute about 90 percent of the cotton grown and they are the largest group in size; while medium scale farmers contribute about 8 percent of the cotton produced. The large scale farmers and privately owned agricultural firms collectively contribute less than 2 per cent of the cotton produced in the country.

The second section is made up of Lintco as a company and it's support services. The company provides the management, inputs and other services directly related to cotton production. The provincial cotton depots and cotton ginneries are also part of this establishment.

The third section is made up of all the secondary support manufacturing industries who make use of cotton or its by products in manufacturing. These include the cotton crushing industry, the food industry; the stockfeed industry; the textile industry and lastly the export sector. The crushing industry takes approximately 62-64 percent of the cotton produced. The food industry takes about 17 percent ot the crushing industry's output with 70 percent going to the feed industry while less than 1 percent is for exports. The remaining amount accounts for losses in the process.

2.3.1 Cotton processing and marketing.

Cotton processing and marketing is the sole responsibility of Lintco. The purchase of cotton by Lintco is carried out through twenty depots and approximately three hundred and fifty permanent and two hundred and fifty mobile centres in producing areas (Southern, Central and Eastern).

Cotton plants produce two marketable products, lint and cottonseed. Cotton lint is the most valuable component, representing 85 to 95 per cent of the farm value of cotton. During the processing stage the cotton seed is extracted from the lint at an extraction rate estimated to be between 36-38 per cent. This rate largely depends on the variety of cotton and the condition of the ginneries.

After the first stage of raw cotton ginning, three products result, cotton seed, planting seed and cotton lint. The cottonseed is further processed into oil, cakes or meals and hulls, all of which have commercial value. Oil is basically for human consumption, the meal cake and hulls are combined to make stockfeeds. From cottonseed, linters are also produced. These are used in furniture manufacturing.

Planting seed accounts for only 2 percent of the raw cotton, while cotton lint, accounts for about 36 percent. Cotton is further processed into textiles for both domestic and export markets. In a complete ginning process, one tonne of unprocessed cottonseed will yield 170 kg of oil, 470 kg of meal, 230 kg of hulls, 80 kg of linters, and 50 kg is assumed for loss in manufacturing (Hutchnson, 1985). Figure 2 gives a breakdown of the components of processed cottonseed.

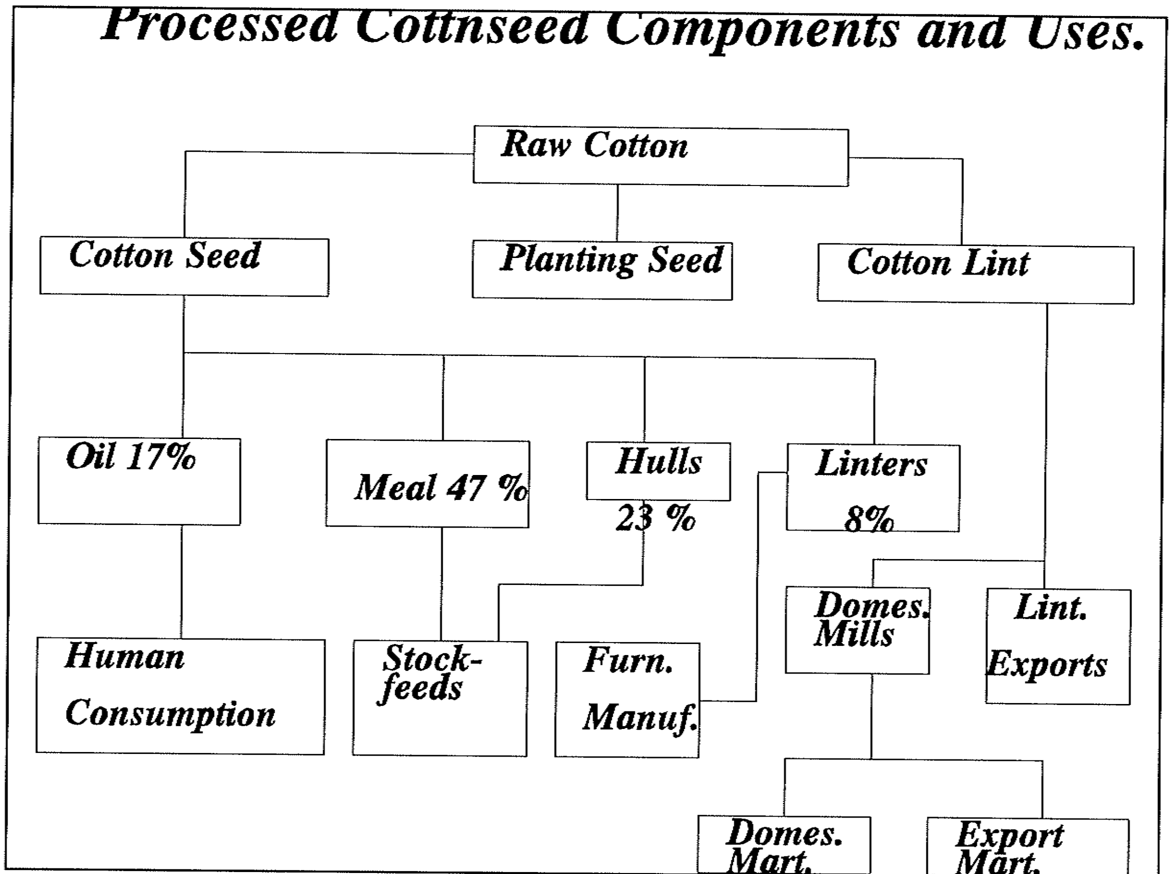

Figure 2: Cotton Seed Components and Their Uses

SOURCE: An Economic Analysis of Expanding Cotton Exports in Zambia, Unpublished Thesis, University of Manitoba, Winnipeg, Canada, 1990.

2.3.2 Cotton Lint Classification

Until 1974, cotton was classified into three official grades, A, B, and C based on the colour of the lint,(A being the best and C being the worst). The prices of each grade were determined by the government. This classification did not continue because the government was unable to maintain uniformity in the grading procedures due to the lack of properly trained personnel. Another reason for the discontinuation of cotton grading was size and distribution of the crop. With cotton production spread unevenly in remote parts of the country, the government did not have the resources to provide extension services for cotton grading. After 1974, cotton had one price irrespective of the quality of the cotton being sold.

2.3.3. Constraints to cotton production

At both farm and institutional levels, small scale cotton farmers have faced a number of constraints. Major constraints affecting the farmer directly include low yield potential of the crop. The sole dependence on weather (rainfall) is the main non-economic constraint. All the other constraints to cotton production are related to economics at the farm level and marketing. The economic disincentives to small scale production are:

1. the inability to plant early, due to lack of labour, financial resources, input supplies and technical information.
2. limited market outlets, and;
3. unattractive prices.

Another constraint in the subsector has been the erratic payments to farmers for their produce. This has destroyed the enthusiasm that farmers had at the time LINTCO was instituted.

In addition, at the institutional level, support for cotton production, has been minimal. There has been little or no training in personnel and resource management (FAO,1992). As such the management systems that have been established to organize and control production have been marginalised.

The shortage of investment and operating capital has been another constraint. Both public and private sectors lack investment and working finance due to stringent monetary and fiscal measures.

The transportation of produced cotton from the temporary farm level or district storage sheds has been a constraint in increasing cotton production. Lintco does not have enough trucks to transport cotton from all growing areas. As a result the company has resorted to hiring privately owned trucks at a high rate and this has increased the company's costs. Though the company has been able to hire trucks, they have not been enough to cover all the growing areas before the onset of the rain season. As such some of the cotton has been going bad. Also, the feeder roads are in poor condition and in some areas have been neglected. This has resulted in late deliveries of seed and other inputs for cotton production. This is an example of an unfair government policy. Small scale farmers can only be reached given good feeder roads. These constraints at the institutional and farm levels have considerably contributed to the low yields and subsequently low growth rates in the subsector.

2.4 Credit aspects in agriculture.

The credit system plays a major role in agricultural operations in Zambia. The availability of adequate and timely credit to farmers is crucial to the purchase of needed farm implements, inputs and working capital requirements. This is particularly so among large scale farmers whose operations are capital intensive and input dependent. Credit is also a key ingredient in the marketing of agricultural output because marketing entrepreneurs and institutions must raise the necessary funds in advance to finance the purchase of produce from farmers. The amounts of crop finance required for this purpose are very large thus necessitating some form of a bridging facility.

Most of the commercial banks in Zambia are involved in agricultural credit operations. In most cases, however, their credit disbursements have been biased towards large scale commercial farmers. However, rural credit institutions, notably, the Zambia Cooperative Federation and the Credit Union and Savings Association have been involved in credit disbursement operations to small scale farmers. Parastatal companies,too, have been engaged in credit operations. These companies often make a contribution to the crops they support. An obvious example is LINTCO which offers credit to small scale cotton producers.

The main institutional bank associated with credit to small scale farmers has been Lima Bank, which was created by the government to alleviate problems associated with agricultural lending to this particular group of farmers. Its operations started in 1987, with assets taken over from the then Agricultural Finance Corporation and the Zambia Agricultural Development Bank. The number of loan application received and approved by Lima Bank since it was formed are shown in Table VI.

Table IV: Loan Applications received by Lima Bank, 1987-1990.

Year	No. Received	No. Approved	% Rejected
87/88	77,258	36,969	52
88/89	77,714	46,148	41
89/90	75,442	44,252	41

SOURCE: Food and Agricultural Organization Report,1992.

The summary indicates that in general, the number of loan applications has marginally declined but the number and proportion of successful applicants has increased slightly. The analysis of Lima Bank's loans by size of farmer is presented in Table V.

Table V: Lima Bank: Analysis of Agricultural Lending, 1987-1990.

(in Zambian Kwacha)

Type of Farmer	1987/88	1988/89	1989/90	1990/91
Small	77,419	118,737	401,305	226,237
Medium	6,022	12,336	49,544	41,475
Large	2,581	23,131	44,589	79,988
TOTAL	86,022	154,204	495,438	347,300

SOURCE: Food and Agricultural Organization Report,1992.

The above figures show that although small scale farmers have remained the biggest group of borrowers, in terms of value, there has been faster growth in lending to medium and large farmers. The tables also show that between 1989 and 1991, the value of loans awarded to small scale farmers fell by almost 50 percent.

There have been a number of constraints to the expansion and delivery of agricultural credit. The main one has been lack of liquidity in the main financial institutions which has been as a result of the restrictive monetary measures. The Central Bank requires the commercial banks to maintain a statutory reserve of 28 percent of their deposits. The banks are further required to keep at least another 28 percent of their deposits in the form of treasury bills. This implies that at least 56 percent of the total deposits raised by the banking system are not available for lending. Competition for the remaining 44 percent is extremely uneven. Since the Central Bank does not require the banks to target a specific proportion of their portfolio funds to agriculture. The commercial banks prefer to lend to commercial and manufacturing sectors where risks are less, credit administration costs relatively less costly, and the turnover of funds more brisk.

The other constraint has been high interest rates and charges to agricultural loans. This has hindered the small scale farmers from borrowing, and hence have affected their production capacity.

In addition, due to lack of collateral small scale farmers have not been able to borrow from the banks. Land has not been accepted by commercial banks as collateral because the land is traditionally owned, and in principle it is state owned.

2.5 Land tenure system in Zambia

Land ownership is an important aspect in agricultural production. The land tenure system in Zambia is derived from the colonial pattern that was initiated before independence. It can be divided into three categories:

1. **State Land:** By definition all land in the country is owned by the state, and provision of land either for private, industrial or agricultural purposes is at the discretion of the state. Within this category, there are sub-categories. These are:-

i) **State Farms:** These are portions of land set aside for particularly farming purposes by state institutions. The Zambia National Service has been the predominant participant in state farming activities, which contribute approximately 5 percent of large scale agricultural production.(Csaki, Metzger, Van Zyl 1992) ii) **Estate Farms:** These portions of land are owned by the state, but managed by private companies depending on the crop that is being grown. There are currently two estate farms in the country.

iii). **Cooperative Land:** Cooperative agriculture has been in existence since 1970. These are communal farm units and as such ownership is communal and the title deeds are issued in the name of the cooperative.

2. Trust Land: Under this category, the land has either been given out by the state agency at a minimum fee and a 99-year land lease. It could also have been purchased by the owner from an individual who owns tittle deeds to the portion of land. This type of ownership is most prevalent among the large scale farmers. In this category, there also exists tenants who have acquired land through customary laws.

3. Reserve Land: Traditional land is mainly owned by small scale farmers through traditional inheritance laws. By definition, however, the state owns this land that accounts for 60 percent of agricultural settlement. The settlers on this type of land mainly do not have title deeds and the land cannot be used as collateral for credit purposes from commercial banks. Figure 3 shows land types in Zambia as a percentage of total area:

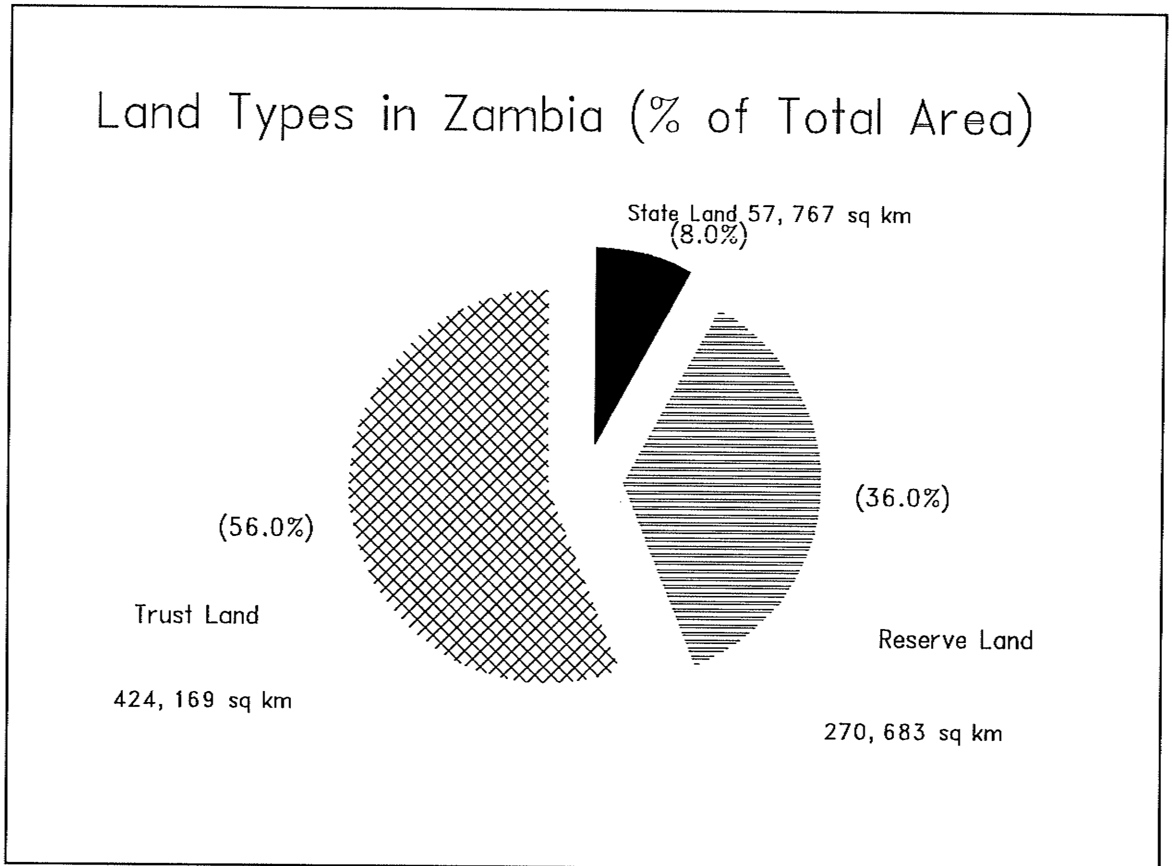

Figure 3: Land Types in Zambia (% of Total Area)

SOURCE: The Weekly Post, No. 110 August 13-19, Lusaka, Zambia.

CHAPTER 3

REVIEW OF LITERATURE

There is substantial literature on agricultural productivity and risk analysis. Each of these studies have analyzed the problems in different ways.

3.1 Productivity measurements in agriculture.

Nadri(1970) defines productivity in terms of the efficiency with which inputs are transformed into useful output within the production process. He used an earlier approach to productivity measurement based on ratios of a measure or index of aggregate output divided by the observed quantity of a single input, typically labour. These productivity ratios were normalised to a base year resulting in a productivity index used to measure aggregate productivity for the entire economy.

In 1964, Schultz suggested that peasant agriculture might be indeed efficient within the context of traditional agricultural technology and factor availability. Since then, a lot of studies have been done to test this. Schultz did his studies on efficiency in India and Guatemala. He tested the hypothesis that there were comparatively few significant inefficiencies in the allocation of factors of production in traditional agriculture. The factors of production under these circumstances consist of traditional factors and the hypothesis was restricted to those factors which were at the disposal of the particular community. In both situations he drew inferences that there were no significant inefficiencies in the allocation of factors of production that were available to the farmers and hence his 'poor but efficient'[1] hypothesis was not rejected.

In 1971 and 1972, Lau and Yotopolous developed an operational concept of economic efficiency to measure and compare the performance of farm firms. They tested relative efficiency of small scale and large scale farmers using a Cobb-Douglas profit function. In formulating the test for equal relative economic efficiency, they used McFadden's profit function which expressed the firm's maximised profit as a function of prices of output and variable inputs of production. The results of this test were suggested that small scale farmers were efficient.

In measuring the relative efficiency in wheat production of new and old varieties in the Indian Punjab, Sidhu 1974, found that there were no differences in economic efficiency between the small and the large farmers. The above two studies, therefore agreed with the earlier study by Schultz, that small scale farmers are indeed efficient, ant this can be generalised across all small scale farmers.

3.2 Risk and Uncertainty in Agriculture.

Whilst the importance of measuring productivity and economic efficiency is an important aspect of production economics, it is evident from most literature that measurement of agricultural productivity and efficiency in any type of agricultural production is not complete without acknowledging and incorporating risk and/or uncertainty. It is because of the riskiness and uncertainty in agriculture that hinders

[1] Schultz.T.W, Transforming Traditional Agriculture, Yale University Press, London, 1964. page 44.

accurate productivity and efficiency considerations. Furthermore little has been done in terms of farmer decision making analysis in African agriculture, and the importance of risk in any production analysis model.

Small scale farmers in the Third World are faced with a lot of risky situations during which the farmer has to make decisions to grow or not to grow. The weather situation is erratic and in general these farmers do not benefit from government policy initiatives. The technologies that are employed in this sector are traditional and the factors of production are not easy to come by which poses a lot of risk to the farmer(FAO, 1992). It is this kind of risky atmosphere under which the farmer has to make his decisions. Therefore, fundamental production decisions cannot be isolated from risk management considerations. This has been supported by Hazell(1982) who argued that if risk is omitted from farm management models, production response will be overestimated.

Just and Pope (1981) developed a production function that allows input levels to affect risk as defined by the variance of output, independently of their effect on the level of output. Such functions have had enormous generality regarding the role of inputs in determining the random nature of output.

Freund, Yasser and Zilberman (1979, 1982, 1983), have also done extensive studies on input allocation decisions. They used stochastic dominance and mean variance approaches. They applied comparative statics to show that a risk averse firm will use more or less of a production factor than will a risk neutral firm if the input decreases or increases output variance.

Among the first to incorporate the effects of risk in assessing alternative agricultural policies was Just(1974). He presented an empirical investigation of the importance of risk in farmer decision making using an adaptive expectations model.

While some studies have omitted the importance of risk and uncertainty in subsistence agriculture, other studies have tried to model such in analyzing risk preferences and resource allocation among farmers.

Studies done by Falcon(1964) and Mellor(1966) have hypothesised that land availability has caused small farmers to be risk averse in their planting decisions. The assertion is that fluctuations in prices and/ or yields have led the small farmer to grow a large portion of the land with food crops which promise a lower expected return than the cash crop. Such analyses have been refuted by later economists, such as Wright and Kunreuther(1979) who have showed that in many cases farmers with the smallest land available would plant a larger portion of it with cash crops. In this study it was found that small scale farmers are always in a position to gamble. One possible explanation for this was that they had a Von Neuman-Morgenstern utility function which decreases sharply at some critical income level so that they would prefer to gamble in order to avoid poverty. Such behaviour patterns depict levels of risk aversion in farmer decision making.

Another study by Ortiz(1979) looked at the effects of risk aversion strategies on subsistence and cash crop decisions. A farmer whose subsistence farming can be interpreted as a rational reaction to potential disaster, could be expected to place reliance on that strategy as he gains confidence on the range of yields and the adequacy of cash returns. If prices and yields do not fluctuate that much, the farmer will slowly commercialise. However, uncertain outcomes and incomes force farmers to continue to produce for their own subsistence and accept innovation slowly. It was found that the willingness of peasants to accept risky ventures depended on income and ability to ensure a minimal fund of operation.

Wolgin(1975) developed a model of economic behaviour under conditions of uncertainty among peasant farmers in Kenya. In his earlier analysis, he found that the traditional methods of measuring economic efficiencies are generally misspecified. Therefore in this study, he used a risk aversion model and concluded that risk plays an important part in decision making. Small scale farmers were found to be efficient in their resource allocation.

Other researchers have applied different methods to determine farmer decision making under uncertainty and risk. Holt and Aradhyula(1989) used the rational expectations hypothesis and incorporated a more general analysis that include risk aversion behaviour in the broiler industry in the U.S. The study examined the empirical implications of extending the rational expectations hypothesis to include price risk. The results indicated that price variance is an important aspect in broiler supply.

Though in general all producers are assumed to be confronted with risk and uncertainty, subsistence farmers seem to have more risk associated with their kind of farming activities. This assertion has been supported by a number of studies, notably Foster and Rausser(1991). Their article addresses input decisions under risk of farm failure. As in other risk studies, it is assumed that without risk of failure, the farmer would first maximize expected utility as if he relied only on farm revenue (including off-farm employment if applicable) and then compare this level of farm-derived utility with the utility available elsewhere. It is then assumed that if the farm derived expected utility exceeds the non -farm utility, the farmer remains a farmer.

3.3 Scope of this study

Risk and uncertainty basically arise from three different sources: risk associated with environmental and technological factors such as weather, diseases, pests and improved crop varieties; risk associated with market factors such as supply in other exporting countries, export demand, input supply and competing demand for inputs; and uncertainty with respect to policy changes such as the form of government programs, level of supports and different government regulation. This thesis has considered risk largely in terms of the first two sources- environment and market.

This study relies upon the methodology used by Coyle (1992). In this case, all the input prices and output prices are known a priori, that is they are not stochastic. Another notable difference is that risk only arises from weather variances that affect output. Output has been assumed as a stochastic variable. Therefore, given the above conditions, the approach in this thesis assumes an indirect utility function with a translog cost function.

CHAPTER 4

DATA COLLECTION AND DESCRIPTIVE ANALYSIS

4.1 Study Areas

Agronomical research in cotton production has concluded that cotton is a drought resistant crop suitable for low rainfall and semi-arid regions of Zambia. Evidence supports these results as can be seen from the cotton production trends in Zambia over the years. Figures indicate that cotton production has been most prevalent in Southern, Eastern and Central provinces.

For instance, between 1978 and 1981, these three provinces had the largest contributions of seed cotton intake by official marketing organisations. Though cotton can be and is also grown in other areas, the contribution from these areas in negligible. Figure 4 shows the main cotton growing areas in Zambia.

Primary data were collected from a sample of small scale farmers in Southern and Central provinces. It was not possible to collect the data for farmers in Eastern province because of some logistical problems faced at the time.

Since small scale farmers are a homogeneous group, the results that will arise from this study will and can be generalised to all the small scale farmers who engage in cotton production.

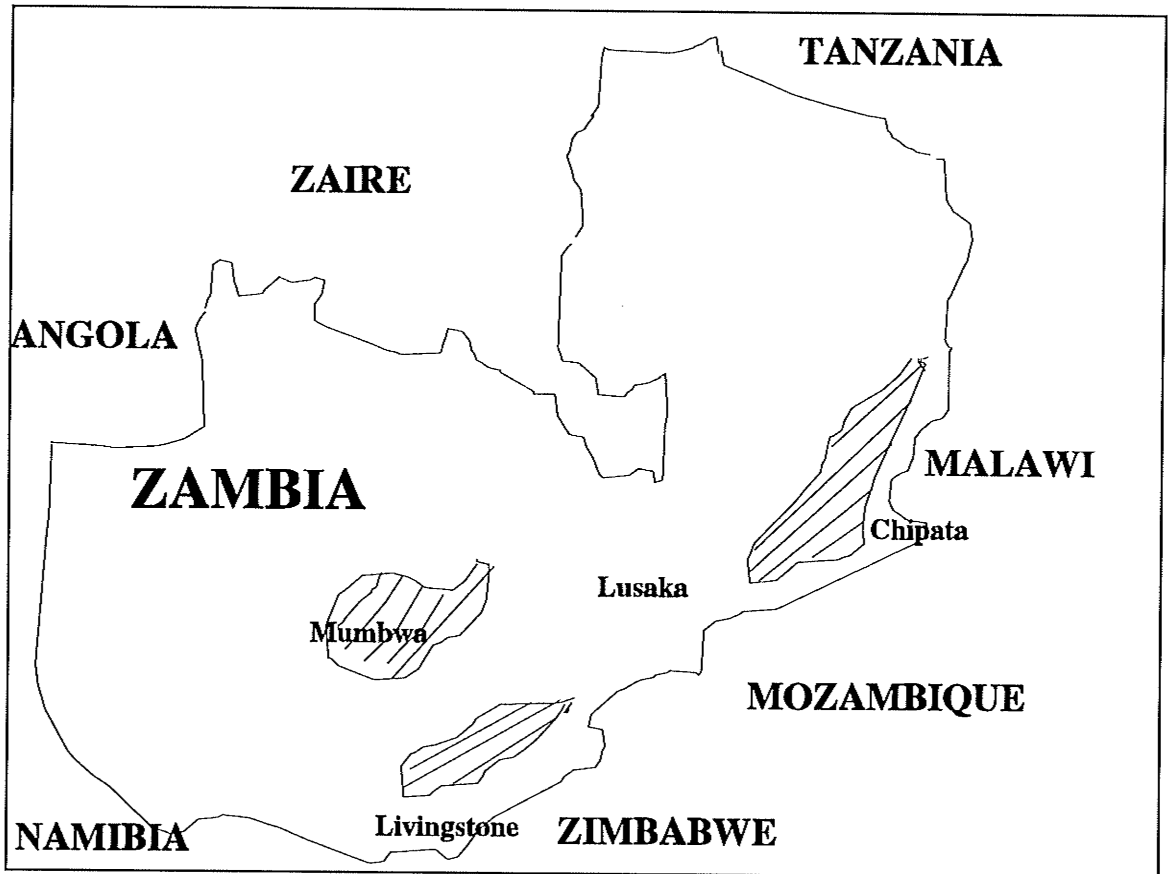

Figure 3: Cotton Growing Areas In Zambia.

SOURCE: Author, 1993

4.2 Data Collected

A questionnaire was formulated to collect data for further analysis. The main objective of the questionnaire was to obtain actual farm level data and input use quantities. The questions highlight actual farmer preferences in cropping patterns. This involved qualitative responses as to why the farmer was growing the particular crop and what in the farmer's view were the impediments to increased agricultural production.

A non-random sampling method was used to collect the data. This was based on the information obtained at the district level extension office. Farmers were identified in each region based on proximity and accessibility.

A total of 90 farmers were selected from the Southern and Central provinces. In the southern province, a total of 50 farmers were interviewed. Further analysis showed that 20 farmers out of the 50 did not respond well. They had no knowledge of how much they had invested in agriculture. Therefore these farmers were eliminated from the study. Further analysis also showed that 15 of the 50 farmers did not have complete information, in terms of area under cultivation, seed use and, fertiliser use. Because there was no other way of approximating actual farm input usage, these farmers were also not used in the actual econometric analysis. The remaining farmers had all the information in terms of hectarage and input use and all the input prices during the years in review. Because of the availability of all the information required, only 15 farmers were used in the empirical work.

Central Province had a better farmer response percentage because more farmers in the sample were literate than in the Southern province. Out of the 40 sampled from the area, 16 farmers had complete information for all the years in review; 10 farmers only had complete information for two years; 15 of the farmers had complete information for only one year. The rest did not have complete information for any particular year. It is important to mention that it was difficult for extension officers to fill in data gaps because of lack of records in most cases. For uniformity, only 15 farmers from the Central Province were used in the analysis for the period, 1985 to 1990. The following data sets were used in the analysis:-

i) output quantities; cotton and maize :

The output quantities at farm level were collected from each farmer for six years. The quantities for cotton were collected in kilograms as marketing is done in these units. These are the total kilograms of cotton produced in the particular year. The quantities for maize were collected in number of 90 kg bags produced for each year.

ii) labour endowment:

All the farmers interviewed use family labour, and it is important to cost this labour, because of the opportunity cost that is involved. The labour input was collected in terms of the number of able bodied men and women per farm family who actively contribute in the actual production process of each crop. Also collected were the approximate number of hours that each household spent in crop production and harvesting. These were divided into hours allocated to planting, weeding and thinning, spraying/ and or fertiliser application and harvesting.

iii) prices on seed, fertilisers,insecticides:

The prices for cotton seed were obtained from LINTCO. The company supplies cotton seeds to all cotton farmers at a price that is set between the government and Lintco. This price is uniform in the whole country.

The prices for maize seed were obtained from the Zambia Seed Company (ZAMSEED). The company deals in seed marketing of most of the crops but cotton. Maize seed prices of the different varieties were uniform in most parts of the country.

Fertilisers and insecticides prices are the same in most parts of the country. The prices that are used are the per unit prices, a unit being kilogram for maize and cotton seed and for fertiliser, and a liter for insecticide.

iv) seed, fertiliser and insecticide quantities

Seed quantities for maize and cotton and insecticide were collected in terms of kilograms for the area planted. These are the actual quantities that the farmers used in the production process for each particular year.

v) rainfall

In any study of small scale agriculture, it is rather difficult to obtain actual farm level weather variables. No structures have been set for this. Therefore, the general weather variable is replaced by rainfall averages for the regions. Though this does not give the variation required at farm levels, it will help explain the variances in output as these rainfall levels generally are the averages for the areas where the farm data was collected.

4.3 Descriptive Analysis and Farmer Responses

Though cotton and maize have mostly been grown in the Central and Southern provinces, farmers in other provinces have also been producing these two crops. In Southern and Central provinces, small scale farmers have been growing other crops such as sorghum and sunflower. However cotton and maize have been most significant for the small scale farmers in these two provinces and on a cumulative basis, the production levels have been increasing over the years.

Despite the increase in production levels, the farmers faced a number of constraints. The following were identified by most of the farmers interviewed:

a) Late payment of produce purchases

Late payment has been identified as one of the major constraints to increased agricultural production. The paying period has been between 3 to 5 months and into the planting season, which makes it difficult for the farmers to plan. This has tended to shift farmer's preferences to other crops that are not affected by this problem, such as sorghum and sunflower.

b) **Late deliveries of inputs**

Both Lintco and the maize buying agents have repeatedly failed to deliver inputs to the small scale farmers on time. This had lead to late planting and late application of fertilisers and insecticides. Delays in this critical timing of crop production results in lower yields.

c) **Low output prices**

Most farmers have argued that the government fixed prices are low and do not consider the production costs that the farmer incurs. Most of the inputs (fertilisers and insecticides) are imported and hence expensive. This has reduced the average margin the farmer gets, therefore making agriculture quite unprofitable. This argument can further be supported by the following comparisons between maize and cotton real input and output prices over the years.

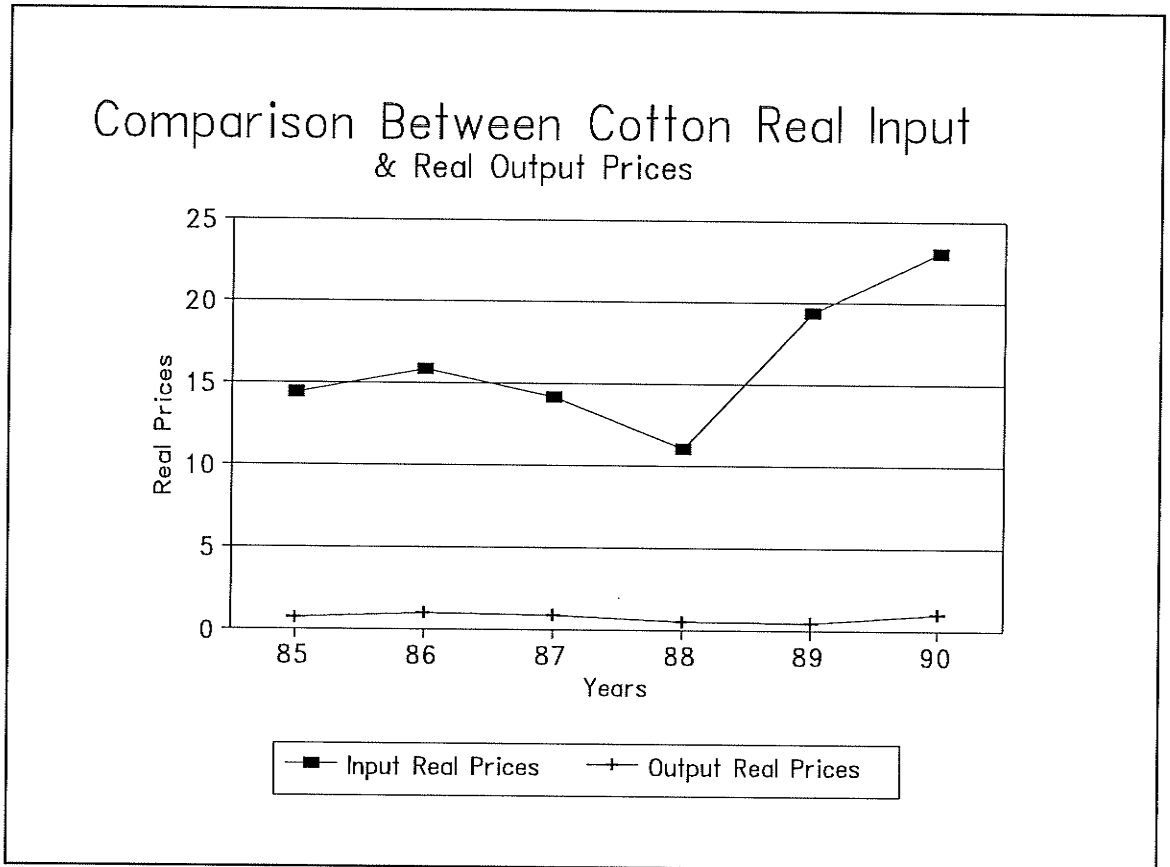

Figure 4: Comparison Between Cotton Real Input and Output Prices, 1985-1990.

As can be seen from figures 5 and 6, for both crops, increases in the government set prices have been much below the changes in the input prices.

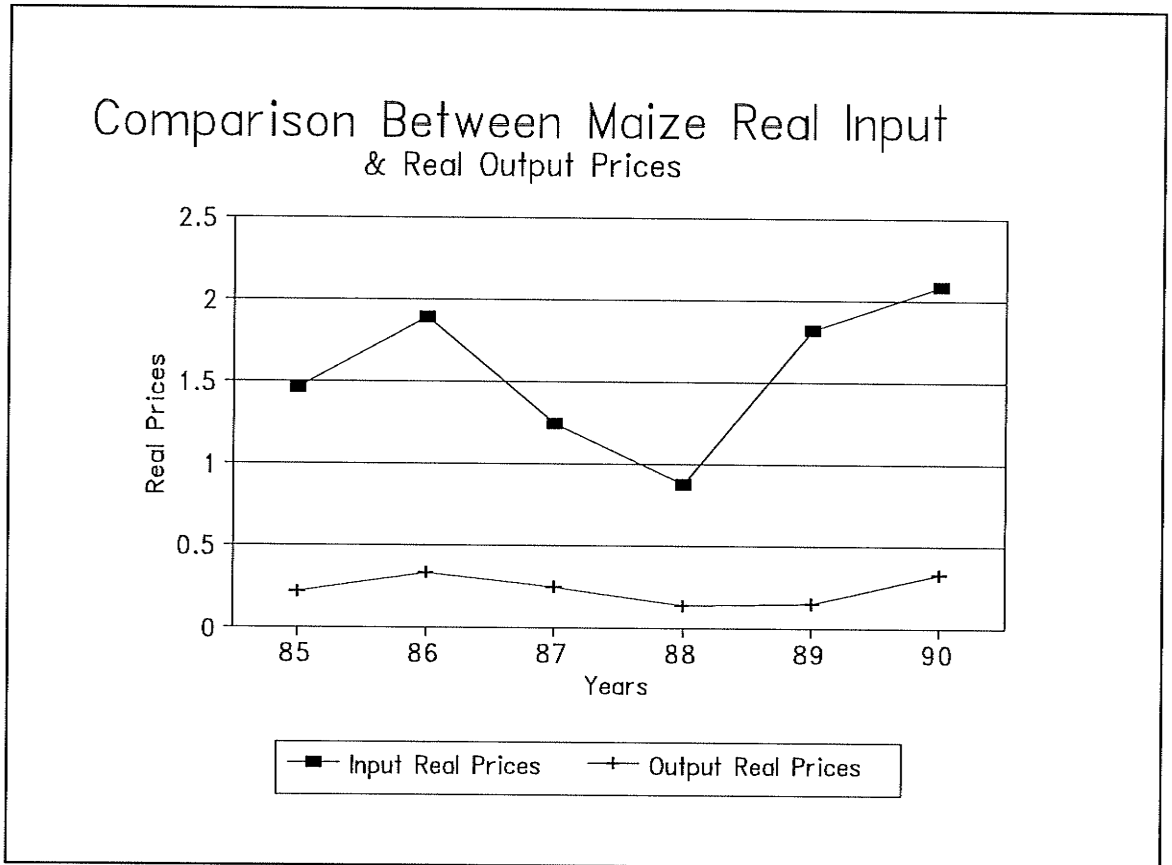

Figure 5: Comparison Between Maize Real Input and Output Prices, 1985-1990

The farmers would therefore like to see high output prices that would provide a bigger margin for their output.

d) Lack of adequate storage facilities

Farmers argue that most of their produce have been destroyed in years of early rainfall because they lack adequate storage facilities. Farmers are not able to develop on farm storage facilities because they lack enough money. In addition, buying agents and Lintco have not made storage a priority. In most cases farmers have reduced the amount of land allocated to these crops.

e) Lack of adequate transport facilities

Most small scale farmers use animal power to transport produce and inputs. Such slow transport is not ideal for longer distances and in times of bumper harvests. Therefore, Lintco and the maize buying agents have always provided transport. They seldom provide enough transport however, which results in more post-harvest losses.

f) Lack of good roads

The feeder roads that connect farmers to the markets are not in good condition, and no efforts have been put towards improving these roads. This has made it difficult to transport both inputs and output, which results in late deliveries and output losses.

g) Lack of operating capital

Farmers argue that they have been unable to save money from output sales because of the low output prices. This has made the farmers dependent on seasonal loans based on inputs from Lintco. Though this has enabled them to plant the crop, other expenses have been hard to meet. Labour has been scarce, because of their inability to pay for it, and hence they have restricted themselves to the most basic and cost saving agronomical practices. This has further reduced the average yield levels.

Apart from the above constraints, farmers have argued that government as an institution has failed to improve the status of small scale farmers. It has been argued that most of the incentives that have been offered in the agricultural sector have benefited mainly the large scale farmers. They have also argued that efforts have been concentrated on maize production and national food security at the expense of traditional exportable crops like cotton.

The following areas have been identified as possible areas for change:

i) Agricultural Pricing Policy: Farmers have argued that they should have a say in the pricing of their produce.

ii) Input and output deliveries should be a priority in government policy.

iii) Rural Development should also be a government priority.

iv) Government should make more finances available for lending to small scale farmers.

CHAPTER 5

EMPIRICAL MODEL AND RESULTS

5.1 Theoretical Framework

Though it may not be necessary to trace out the development of the neoclassical model of behaviour under conditions of uncertainty, it's main features can be outlined.

5.1.1 The utility function and it's basic assumptions

The decision maker is assumed to be maximising an expected utility function, with one argument, which is income, that in itself is a random variable with a known distribution.

The objective function maximising expected utility can be derived by imposing some basic assumptions relating to transitivity and continuity of the utility function (Von Neumann and Morgenstern). The expected utility function provides a single valued index that orders action choices according to the preferences or attitudes of the decision maker. The objective function of maximising expected utility can be derived by imposing some basic assumptions. These axioms are considered conditions of how people behave, and amount to a general assumption that people are rational and consistent in choosing among risky alternatives. The set of axioms is summarised below (Barry 1984):

1. **Ordering of choices**: For any two actions, **A1** and **A2**, the decision maker either prefers **A1** to **A2** prefers **A2** to **A1**, or is indifferent between them.
2. **Transitivity among choices**: If **A1** is Preferred to **A2**, and **A2** is preferred to **A3**, then **A1** must be preferred to **A3**.
3. **Substitution among choices**: If **A1** is preferred to **A2**, and **A3** is some other choice, then a risky choice **PA1 + (1-P)A3** is preferred to another risky choice

   PA2 +(1-P)A3, where **P** is the probability of occurrence.
4. **Certainty equivalent among choices**: If **A1** is preferred to **A2**, and **A2** is preferred to **A3**, then some probability **P** exists that the decision maker is indifferent to having **A2** for certain or receiving **A1** with probability **P** and **A3** with probability **(1-P)**. Thus **A2** is the certainty equivalent of

   PA1 + (1-P)A3.

If these axioms hold, then an optimal risky choice can be based on the maximisation of expected utility and an individual will always choose the prospect which yields the highest expected value of utility, usually expressed as a function of income or wealth.

Theory says that a concave function implies risk aversion, a convex function implies risk preferring and a linear function implies risk neutrality. It is also possible for a decision maker to have a utility function with both convex and concave segments indicating changes in attitudes for monetary outcomes.

5.1.2. Production function choice and risk analysis.

In any production analysis, henceforth risk analysis, production theory gives a number of postulates which are necessary in analyzing technical input-output relationships and in this instance, the discussion of risk will be confined to arguments relating to variance other than other higher moments, since normality will be assumed in the analysis. In this analysis, the following postulates have been considered:-

1. Positive production expectations, $[E(q) > 0]$.

2. Positive marginal product expectations, $[\partial E(q)/\partial X_i > 0]$. This is consistent with production theory. Only factors which have a positive marginal contribution need to be considered.

3. Diminishing marginal product expectations, $[\partial^2 E(q)/\partial X_i^2 < 0]$. This postulate corresponds to the usual concavity conditions.

4. A change in variance for random components in production should not necessarily imply change in expected output when all production factors are held fixed, $[\partial E(q)/\partial V(E) = 0]$.

5. Increasing, decreasing or constant marginal risk should all be possibilities, $[\partial V(q)/\partial X_i <,=,> 0 \;\; where V(q) = E\,[q-E(q)]^2]$.

6. A change in risk should not necessarily lead to a change in factor use for a risk neutral profit maximising producer, $[\partial X_i^* / \partial V(E)] = 0$ *where* X_i^* is the optimal input level

7. The change in the variance of the marginal product with respect to a factor change should not be constrained in sign a priori without regard to the nature of the input, $\partial V\ [(\partial q/\partial X_i)/\partial X_j]\ <,=,>\ =0$

8. Constant returns to scale should be possible, $F(\alpha X) = \alpha F(X)$ *for scalar* α.

In choosing a production function, the above postulates have to be considered.

5.1.3 Theory of utility maximisation and risk considerations.

Economic analysis of production relations can be divided into two areas. First, analyses that involves normative economics of efficiency in production and planning. Second, positive economic analysis of production responses to changes in economic factors. Such factors could include government policy; demand structure and availability of markets.

Introduction of risk analysis in production models has broadened the use of positive economics in analyses of econometric supply. Two basic approaches of primal and dual have been used in this area. The primal approach was pioneered by Marshak and Andrews(1982) in the case of certainty. However, the duality approach has also been introduced in such analyses.

The principal advantage of using duality theory in the specification of a system of supply and demand equations that are consistent with maximising behaviour is that it allows the derivation of supply and demand equations as derivatives of a function than the solution to the problem. This methodology also allows use of more flexible functional forms.

Many analyses have suggested that producers are a risk averse entity and maximize expected utility of profits rather than simply profits (Young, et al 1984). Therefore if risk behaviour is ignored, then the firm's responses to any changes in the system will either be overestimated or underestimated.

Assuming that there exists no price uncertainty in the environment, and also assuming that instead their exists production uncertainty arising from weather variations, consider the following mean-variance utility maximisation function:

$$U = U\ [\ E(\pi), V(\pi)\ ] = U(E,V) \qquad \textbf{(1)}$$

And the equation above can be explicitly defined as:

$$U = E\pi - \frac{\delta}{2} V\pi \tag{2}$$

where $E(\pi) = pEy - wX$

$V(\pi) = p^2 Vy$

δ is the coefficient of risk aversion

Because the farmer is also a profit maximising entity, the profits are defined as:

$$\pi = pq - wX \tag{3}$$

where p is output price

q is output quantity

w is a vector of input prices

X is a vector of input quantities used in producing the output.

Assume a production function that incorporates the stochastic weather variable as $y = f(X,\omega)$. Therefore the mean and variance of weather are denoted as $E\omega$, $V\omega$, and the mean and the variance of output, given stochastic weather are given as:

$$Ey = f(X, E\omega)$$

$$Vy = [\partial f(X, E\omega)/\partial\omega]^T \, V\omega \, [\partial f(X, E\omega)/\partial\omega]$$

The indirect utility function is specified on the basis of the assumptions that both the mean and variance of output will depend on the mean and variance of the stochastic variable, weather, which is normally distributed, and that the variance of output is linear in the variance of the same stochastic variable.

Therefore considering the postulates, assume the following Just-Pope production function:

$$y = f(X) + h(X)^{\frac{1}{2}}\omega \qquad , E\omega = 0 \tag{4}$$

Given the relationship of the mean and the variance, then from the equation above:

$$Ey = f(X) \tag{5a}$$

$$Vy = h(X) \, V\omega \tag{5b}$$

Unlike the Just-Pope primal methodology, the duality approach specifies output supplies conditional on the mean and the variance of weather. The model will specify a system of expected supply, input demands and variance of output in terms of the exogenous variables including weather. Therefore substituting equation (5a) and (5b) into the equation (2), the indirect utility function is specified as:

$$U^*(p,w,\theta) = \max_{X\geq 0} U(X;p,w,\theta) = pf(X) - wX - (\frac{\delta}{2})p^2h(X)/\theta \qquad (6)$$

where $\theta = \frac{1}{V\omega}$

Assuming the existence of the indirect utility function above, the following properties of the function are assumed to exist:-

i). increasing in output prices,(p), decreasing in input prices, (w) and increasing in $1/V\omega$.

ii). linear homogeneous in $(\boldsymbol{p},\boldsymbol{w},\boldsymbol{\theta})$.

i.e $U^*(\lambda p,\lambda w,\lambda\theta) = \lambda U^*(p,w,\theta); \quad \lambda>0.$

iii). Assuming that the indirect utility function is once differentiable, then applying the envelope theorem, then:-

$$\frac{\partial U^*(p,w,\theta)}{\partial p} = Ey(X^*) - \alpha p Vy(X^*)$$

$$\frac{\partial U^*(.)}{\partial w_i} = -X_i^* \qquad (7)$$

$$\frac{\partial U^*(.)}{\partial \theta} = (\frac{\delta}{2})\, p^2 Vy(X^*) V\omega$$

iv). Assuming twice differentiability of the indirect utility function, then the Hessian matrix is symmetric positive semi-definite.

Equation (7) implies a reduced form expected supply equation:-

$$Ey(X) = \frac{\partial U^*(p,w,\theta)}{\partial p} + (\frac{2}{pV\omega})\,\frac{\partial U^*(p,w,\theta)}{\partial \theta} \qquad (8)$$

To estimate the expected output supply and factor demand relations given the assumptions of a linear mean-variance utility function and a Just-Pope production function, a second order flexible functional form for the dual utility function $U^*(p,w,\theta)$ need be specified. The functional forms for the expected output supply and factor demand equations are given by equation (8).

The policy variables, $p,w,V\omega$ are related to the expected output, input levels and variance of output, consistently with equation (6) and the production function specified.

5.1.4. Cost function approach in dual production analysis

One of the methods used in production analysis under risk has been the indirect utility approach (Coyle, 1992). To specify and solve a producer decision problem under yield uncertainty, using a stochastic dual cost function approach is essential. In this specification, farmer decision will depend on only the mean and variance of profits and this will in turn depend on the mean and variance of the probability distribution of output.

Therefore, the maximisation of utility, implies cost minimisation conditional on the mean and variance of output (Coyle, 1992). It is assumed that factor prices are known a priori and with certainty and that a general mean-variance utility function describes all risk preferences.

The cost minimising choices of inputs conditional on the expected output, Ey, variance-covariance of outputs, Vy and normal distribution parameters of weather (ω), $E\omega$ and $V\omega$; are specified by the dual cost function as:

$$C(w, Ey, Vy, E\omega, V\omega) = \min_{X \in V(Ey, Vy, E\omega, V\omega)} wX \qquad (9)$$

where $V(Ey, Vy, E\omega, V\omega)$ is a feasible set of input vectors X conditional on $(Ey, Vy, E\omega, V\omega)$.

The properties of the cost function regarding factor prices, w are:-

i). Linear homogeneity in w, i.e $C(\delta w, Ey, Vy, E\omega, V\omega) = \delta C(.....)$.

ii). The function is concave in w, i.e

$$C(\delta w_A + (1-\delta)w_B, Ey, Vy, E\omega, V\omega) \geq \delta C(w_A, Ey, Vy, E\omega, V\omega) + (1-\delta)C(w_B, Ey, Vy, E\omega, V\omega).$$

iii). Sherpard's lemma applies. i.e

$$\frac{\partial C(w, Ey, Vy, E\omega, V\omega)}{\partial w_i} = X_i^*.$$

Therefore given the cost function, the producer's indirect utility maximisation equation can be written in terms of the dual cost function as:-

$$U^*(p, w, E\omega, V\omega) = \max_{(Ey, Vy) \in Y} pEy - C(w, Ey, Vy, E\omega, V\omega) - \frac{CRA}{2} p^T Vy\, p \qquad \textbf{(10)}$$

where: $p^T Vy\, p = p_i^2 \; var\; y_i + p_j^2 var\; y_j + 2p_i p_j \; cov(y_i\; y_j)$.

Given that the cost function takes a certain functional form, then the empirical model for the producer's choice problem can be given by the following properties:-

i). Sherpard's lemma

This gives the optimum levels of input demand. This implies that these demand equations are homogenous of degree zero and the Hessian matrix of second order derivatives is negative semi-definite.

If the cost function describes the decision process of the farmer, then the following symmetry conditions will hold. That is:-

$$\partial X_i(..)/\partial w_j = \partial X_j(..)/\partial w_i$$

ii). First order conditions for an interior solution:

$$\begin{aligned}
\frac{\partial U^*}{\partial Ey_j} &= p_j - \frac{\partial C(.)}{\partial Ey_j} = 0 \\
-\frac{\partial U^*}{\partial Vy_{jj}} &= \frac{\partial C(.)}{\partial Vy_{jj}} + \frac{CRA}{2}(p^j)^2 = 0 \qquad i \neq k \\
-\frac{\partial U^*}{\partial Vy_{ij}} &= \frac{\partial C(.)}{\partial Vy_{ij}} + CRA\ p^j\ p^k = 0 \\
\frac{\partial U^*}{\partial X} &= \frac{\partial C(.)}{\partial X} + w = 0
\end{aligned} \tag{11}$$

5.2 Model specification

The farmers in this particular problem are small scale farmers who produce two crops,maize and cotton. The both input and output prices are nonstochastic as the government fixed prices and are known to the farmers well before the planting period.

Land is owned under traditional rights, however, it has been assumed as a fixed input because once a farmer has decided on how much to allocate to each crop, then he will not be able to change that. Labour, too, has been assumed to be a fixed input. None of the farmers interviewed hired any labour because of their financial inability or because of the unavailability of labour.

The issue of technology change is analyzed. The model tests whether these farmers, given risk considerations have positively responded to technical change. To test this, the model has assumed the possibilities of constant returns to scale apriori. Therefore, given the two crops, three inputs and risk, and given a translog cost function, the indirect utility function, can be presented as:

$$U^*(p_c,p_m,w_1,w_2,w_3,X,L,E\omega,V\omega,) = p_cEy_c + p_mEy_m \quad (12)$$
$$- e^{\ln}C(w_1,w_2w_3,X,L,Ey_c,Ey_m,Vy_c,Vy_m,E\omega,V\omega,T)$$
$$-\frac{CRA}{2}[p_c^2\ varEy_c + p_m^2\ varEy_m]$$

where p_c - price of cotton per kg

p_m - price of maize per kg

w_1 - average seed price per kg

w_2 - fertiliser price per kg

X - total labour in mandays

L - total land in hectarages

Ey_c - expected cotton output in kgs

Ey_m - expected maize output in kgs

$E\omega$ - mean rainfall in millimetres

$V\omega$ - variance of rainfall

Vy_c - variance of cotton output

Vy_m - variance of maize output

T - time trend

CRA - coefficient of risk aversion

Given equation (12) above, and applying sherpard's lemma and the first order conditions, the following input share equations, cost shares of expected output, and the variances of outputs are given as:

$$\begin{aligned} S_1 = {} & a_1 + a_{11}\ln(w_1/w_3) + a_{12}\ln(w_2/w_3) \\ & + a_{17}\ln(X/L) + a_{18}\ln L + a_{13}\ln(Ey_c/L) \\ & + a_{14}\ln(Ey_m/L) + a_{19}\ln E\omega + a_{10}\ln V\omega \\ & + a_{15}\ln(Vy_c/L^2) + a_{16}\ln(Vy_m/L^2) + d_1T \end{aligned} \tag{13a}$$

$$\begin{aligned} S_2 = {} & a_2 + a_{21}\ln(w_1/w_3) + a_{22}\ln(w_2/w_3) \\ & + a_{27}\ln(X/L) + a_{28}\ln L + a_{23}\ln(Ey_c/L) \\ & + a_{24}\ln(Ey_m/L) + a_{29}\ln E\omega + a_{20}\ln V\omega \\ & + a_{25}\ln(Vy_c/L^2) + a_{26}\ln(Vy_m/L^2) + d_2T \end{aligned} \tag{13b}$$

$$\begin{aligned} \frac{p_cEy_c}{C} = {} & a_3 + a_{33}\ln(Ey_c/L) + a_{31}\ln(w_1/w_3) + a_{32}\ln(w_2/w_3) \\ & + a_{37}\ln(X/L) + a_{38}\ln L + a_{34}\ln(Ey_m/L) + a_{35}\ln(Vy_c/L^2) \\ & + a_{36}\ln(Vy_m/L^2) + a_{39}\ln E\omega + a_{30}\ln V\omega + d_3T \end{aligned} \tag{13c}$$

$$\begin{aligned} \frac{p_mEy_m}{C} = {} & a_4 + a_{44}\ln(Ey_m/L) + a_{41}\ln(w_1/w_3) + a_{42}\ln(w_2/w_3) \\ & + a_{47}\ln(X/L) + a_{48}\ln L + a_{43}\ln(Ey_c/L) + a_{45}\ln(Vy_c/L^2) \\ & + a_{46}\ln(Vy_m/L^2) + a_{49}\ln E\omega + a_{40}\ln V\omega + d_4T \end{aligned} \tag{13d}$$

$$\begin{aligned} \frac{p_c^2Vy_c}{C} = {} & -\frac{2}{CRA}[\, a_5 + a_{56}\ln(Vy_m/L^2) + a_{51}\ln(w_1/w_3) \\ & + a_{52}\ln(w_2/w_3) + a_{57}\ln(X/L) + a_{58}\ln L + a_{53}\ln(Ey_c/L) \\ & + a_{54}\ln(Ey_m/L) + a_{55}\ln(Vy_c/L^2) + a_{59}\ln E\omega \\ & + a_{50}\ln V_\omega + d_5T] \end{aligned} \tag{13e}$$

$$\frac{p_m^2 Vy_m}{C} = -\frac{2}{CRA}[\, a_6 + a_{66}\ln(Vy_m/L^2) + a_{61}\ln(w_1/w_3) \qquad \textbf{(13f)}$$
$$+ a_{62}\ln(w_2/w_3) + a_{67}\ln(X/L) + a_{68}\ln L + a_{63}\ln(Ey_d/L)$$
$$+ a_{64}\ln(Ey_m/L) + a_{65}\ln(Vy_d/L^2) + a_{69}\ln E\omega$$
$$+ a_{60}\ln V_\omega + d_6 T]$$

Homogeneity of degree 1 in prices has been imposed for the above system of equations by dividing all the input prices by one of the inputs. As such the input share equations have been reduced by one.

The existence of the cost function estimated implies the symmetry restrictions across expected output supply and factor demand equations:-

$$a_{ij} = a_{ji}, \qquad all \quad i, j = 1,.., 4. \qquad (14a)$$

The symmetry restrictions on the variances of output equations are:-

$$a_{ij} = a_{ji}, \quad all \quad other \quad i, j = 1.., 6. \qquad (15a)$$

Cross sectional data is used in this analysis for the two provinces. This has an advantage because it would not understate the variations or uncertainty of yields at the farm level. The measure of weather variation is given by rainfall measure for each region.

Approximations of the mean and variance of weather, that is rainfall were calculated as in Coyle,1992. That is, for each region, **s** and **c**, at time **t**, the mean of weather, $E\omega$ and the variance of weather, $V\omega$, can be calculated as:-

$$E\omega = \omega^{2}_{t-1}$$
$$V\omega^{k}_{t} = 0.50(\omega^{k}_{t-1} - \omega^{k}_{t-2})^2 + 0.33(\omega^{k}_{t-2} - \omega^{k}_{t-3})^2 + 0.17(\omega^{k}_{t-3} - \omega^{k}_{t-4})^2 \quad \textbf{(15)}$$

The mean and the variances of output of the two crops are calculated as:

$$V_{Ey_{j_t}} = 0.50(Ey_{j_{t-1}} - Ey_{j_{t-2}})^2 + 0.33(Ey_{j_{t-2}} - Ey_{j_{t-3}})^2 + 0.17(Ey_{j_{t-3}} - Ey_{j_{t-4}})^2 \quad \textbf{(15b)}$$
$$j = c,m.$$

However, it is important to mention that due to limitations in the availability of data, it has been assumed that farmers have responded to the most recent variation in both output and rainfall and that this variation is the same for an individual farmer, but different from each farmer.

5.3 Hypothesis Testing

Hypotheses testing is done for three model specifications. The first model specification will only consider the input share equations, while the second model specification considers the input share equations and the expected output equations. The third model specification includes all the equations of the model, that is input share equations, expected output share equations and the variance equations.

In the third model,the likelihood ratio test is conducted for each of the hypothesis outlined below. Therefore, assume that L_1 is the log of likelihood function obtained by non-linear estimation of the system of equations (13a-e) and that the conditions (1-8) below are not imposed, and also assume that L_0 is the log of likelihood function of the system derived by the same methodology, but imposing each condition for each test (1-8), then the likelihood ratio statistic is given by the following formula:

$$LR = 2 * [\ln(L_1) - \ln(L_0)] \tag{16}$$

This test is asymptotically distributed as a chi-square under the null hypothesis, with degrees of freedom equal to the free parameters between the two models. L_1 and L_0 are obtained by iterative Zellner's estimation which yields parameter estimates that are numerically equivalent to those obtained by the likelihood estimator. The null hypothesis is rejected if equation **(16)** exceeds the Chi-square critical for specified significance level.

The main hypotheses to be tested in this model are:

1. Hypothesis of cost minimisation implied by the symmetry conditions

2. Hypothesis for insignificance of weather variance

   $a_{i0} = 0 \quad ,i= 1.....6$

3. Hypothesis for insignificance of maize output variance

   $a_{i6} = 0 \quad i = 1.......6$

4. Hypothesis for insignificance of cotton output variance

   $a_{i5} = 0 \quad i = 1.......6$

5. Hypothesis of risk neutrality

   $CRA = 0$. This can also be tested whether, 2,3 and 4 above tested jointly are insignificant.

6. Test for constant returns to scale

   $a_{i8} = 0, \quad i = 1-6$

7. Test for Hicks neutral technical change

   $d_i = 0 \quad i -= 1,2.$

The hypothesis of cost minimisation implied by the symmetry conditions is tested by evaluating whether these conditions are not rejected. If they are not rejected, a further test for the hypothesis is conducted by determining whether the Hessian matrix of the input shares is negative semi-definite. These tests are for CRTS and Hicks neutral technical change. CRTS was evaluated by testing whether the coefficients associated with the quasi-fixed input(land), in the input share equations are all equal to zero.

Then a chi-square test of the hypothesis of Hicks neutral, (interpreted as neutrality of cost shares with respect time trend) was also conducted for the sector, by testing the parametric restriction (coefficients associated with T) in input shares be equal to zero. If the restriction is not rejected, it means that changes in technology did affect substitution possibilities among variable inputs during the period.

5.4 Empirical Results

The share equations of the model are estimated as system of equations using Seemingly unrelated regression analysis. The estimation is divided into three models. The first model is made of the two input share equations, and hypotheses tested on the basis of the results of these equations. The second model consists of the input share equations as well as the shares of expected yield, which are estimated as a system of equations. And the third model consists of the input shares, expected yield equations and the variances of output equations. The third model is estimated using non-linear estimation method. The analytical econometric package used in the analysis is Shazam version 6.2.

5.4.1 Model 1: Input Share Equations

In this model, normalised input share equations are estimated as a system of equations. These equations are tested under conditions of symmetry and no symmetry. The coefficients associated with the input prices are significant and negative. This implies that as input prices increase, the expenditure shares of these inputs reduce. This indicates a downward sloping demand curve. We can therefore, based on this result conclude that the observed decrease in yield can be explained by the reduction in input usage. This has resulted in low output levels and consequently lower gross margins.

Labour has also been found to be a significant factor. This is expected as small scale agriculture in Zambia is basically labour intensive.

However, both cotton and maize yield variances have been found not to be significant in this model. This implies that farmers have not used the variability of their output to determine their production decision. This could be as a result of the misspecification of the model in terms of variance measurements.

The time trend has been found to be significant in the fertiliser shares at 5 percent significance level and significant in the seed share equation at 10 percent significance level when symmetry is imposed. Therefore, there has been some technological change and hence farmers have adapted these changes in their production process.

Table VI: Model 1: Input Share Equations: (Symmetry and No Symmetry Conditions)

SHARE EQUATIONS

	Symmetry		No Symmetry	
Variables	**SEED**	**FERTILIZER**	**SEED**	**FERTILIZER**
Seed Price	-1.5	-0.6	-0.3	-0.32
	(-4.3)*	(-3.5)*	(_5.7)*	(-5.3)*
Fert. Price	-2.4	-0.9	-0.47	-0.12
	(-2.9)*	(-2.8)*	(-6.5)*	(-1.33)
Labour	-0.8	-0.34	-0.39	-0.89
	(-6.2)*	(-8.9)*	(-7.1)*	(-14.9)*
Land	0.89	0.443	0.19	0.038
	(3.5)*	(2.5)*	(4.9)*	(0.9)
Cotton Output	0.46	0.048	0.04	0.018
	(6.8)*	(3.49)*	(7.7)*	(3.09)*
Maize Output	0.004	0.13	0.13	0.059
	(1.53)	(3.09)*	(6.01)*	(2.6)*
Mean Rainfall	-0.002	0.064	-0.002	0.0068
	(-0.48)	(2.01)	(0.25)	(-1.6)
Rainfall Var.	-0.004	-0.005	-0.001	-0.008
	(-0.01)	((0.82)	(0.25)	(-1.6)
Cotton Var.	-0.004	-0.0032	-0.009	0.003
	(0.82)	(0.13)	(-1.3)	(-1.3)
Maize Var.	0.13	-0.043	0.02	-0.02
	(0.18)	(1.05)	(1.3)	(-1.3)
Time	0.002	0.0003	0.0008	0.012
	(2.19)	(2.41)*	(0.13)	(1.85)

Note: * denotes significance at 0.05 significance level

5.4.2 Model 1: Hypothesis Testing

The hypotheses have been tested under symmetry and no symmetry conditions for the input share equations estimated as a linear system of equations. Symmetry, which is a necessary condition for cost minimisation is tested and is not rejected using the Chi-square test. This hence satisfies the necessary conditions for cost minimisation.

The hypothesis of risk neutrality was also tested by jointly testing whether weather and output variances are insignificant in the model. The test is rejected in both symmetry and no symmetry conditions at 5 percent significance level using the Waldi-Chi square test. This implies that farmers are not risk neutral.

The hypothesis of the insignificance of weather variance is also tested using the chi-square test and is rejected at both the 99 per cent and 95 percent levels. This implies that weather variance is an important variable in the model and in explaining farmer behaviour. This variable is also used to test for farmers' risk preferences.

The hypothesis of insignificance of output variances is also tested and the null hypothesis is not rejected. Therefore, this implies that farmers have not responded to variability in yield. This result is a probable outcome of the misspecification of the measurements of output variances.

The hypothesis of constant returns to scale is also tested and CRTS is not rejected. This is consistent with existing production theory.

Table VII: Model: Hypotheses Tested (Symmetry and No Symmetry)

	Symmetry		No Symmetry	
Test	X^2	Degrees of Freedom	X^2	Degrees of
Freedom				
1. Symmetry	---	---	1.98	2
2. Insignificance of Weather Variance	9.34*	2	2.77	2
3. Insignificance of Cotton Output Variance	3.64	2	0.13	2
4. Insignificance of Maize Output Variance	3.74	2	2.35	2
5. Constant Returns to Scale	4.47	2	2.57	2
6. Hicks Neutral Technical Change	9.46	2	13.22	2
8. Insignificance of #2, #3, and #4	8.45*	6	7.08*	4

Note: * denotes rejection of the null hypothesis at 0.05 significance level

5.4.3 Model 2 : Input and Expected Output Share Equations

In this model, normalised input share equations and expected yield share equations are estimated as a system of equations. These equations are tested under both conditions of symmetry and no symmetry. In this model, too, the coefficients associated with the input prices are significant and negative. This implies that as input prices increase, there is a probable reduction in expenditure shares of these inputs. Therefore, it is this reduction in input usage that led to the observed low cotton average yields. These inputs have also been found to be significant in determining the yield shares of cotton and maize.

Labour has also been found to be a significant factor. This is expected as small scale agriculture in Zambia is basically labour intensive and no possibilities of substitution.

However, both cotton and maize yield variances have been found not to be significant in this model. Though this implies that farmers have not used the variability of their yield to determine their production decision, it can also implies some misspecification, especially in modelling variances of output.

The time trend has been found to be significant in cotton and maize output shares. We can therefore say that to some extent there has been some technological change and hence farmers have adapted these changes in their production process.

When symmetry is imposed, there are improvements in the significance of the most important coefficients in the model. Both seed and fertiliser are significant in the yield equations as obtained when symmetry is not imposed. However, contrary to what would be expected, the time trend and the rainfall variance are insignificant in the model. The time trend however, is significant in the yield share equations at 10 percent significance level. The insignificance of the rainfall variance could be as a result of the inaccurate data collected for the variable. The data does not represent actual farm level variance in rainfall. The figures used in the model are regional annual averages that do not necessarily represent on-farm rainfall averages. The following are the results obtained.

Table VIII: Model 2: Input and Expected Yield Equations
(No Symmetry Conditions Imposed)

	SHARE EQUATIONS			
Variables	SEED	FERTILIZER	COTTON OUTPUT	MAIZE OUTPUT
Seed Price	-0.26	-0.4	0.26	1.09
	(-3.5)*	(-5.6)*	(5.7)*	(6.0)*
Fert. Price	-0.4	-0.1	2.4	2.37
	(-6.6)*	(-2.6)*	(7.7)*	(3.8)*
Labour	-0.31	-0.2	0.55	1.43
	(-1.8)	-(1.4)	(2.6)*	(2.9)*
Land	-0.005	-0.006	1.9	1.08
	(-0.33)	(-0.46)	(3.2)*	(0.77)
Cotton Output	-0.07	-0.03	0.03	-0.05
	(5.2)*	(-2.3)*	(0.61)	(-0.4)
Maize Output	-0.08	0.1	0.29	-0.16
	(3.7)*	(5.1)*	(3.8)*	(-1.6)
Mean Rainfall	-0.11	0.2	-0.02	-0.02
	(-1.5)	(3.7)*	(-2.6)*	(-0.69)
Rainfall Var.	-0.003	0.00008	-0.03	-0.03
	(-1.0)	(-0.02)	(-4.1)*	(-1.7)
Cotton Var.	0.002	-0.002	-0.23	-0.01
	((0.6)	(-1.08)	(-1.1)	(-0.69)
Maize Var.	0.004	0.001	0.041	0.03
	(0.2)	(0.97)	(3.6)*	(-1.7)
Time	(-0.006)	(-0.00009)	(-0.008)	(0.006)
	(-0.26)	(-0.46)	(-3.1)*	(3.2)*

Note: * denotes significance at 0.05 significance level

Table IX: Model 2: Input and Expected Output Equations (Continued)
(Symmetry Conditions Imposed)

	SHARE EQUATIONS			
Variables	**SEED**	**FERTILIZER**	**COTTON**	**MAIZE**
Seed Price	-0.27	-0.34	0.1	0.04
	(-5.8)*	(-9.5)*	(8.7)*	(2.6)*
Fert. Price	-0.34	-0.16	0.07	0.14
	(-9.6)*	(-5.4)*	(6.3)*	(10.09)*
Labour	-0.7	0.18	-0.7	-0.48
	(-4.8)*	(1.33)	(-1.2)	(-0.67)
Land	-0.007	-0.009	0.11	0.12
	(-0.48)*	(-0.6)	(1.09)	(0.9)
Cotton Output	0.11	-0.07	0.7	0.16
	(8.7)*	(-6.3)*	(12.1)*	(3.4)*
Maize Output	0.042	0.14	0.17	1.17
	(2.6)*	(10.09)*	(3.4)*	(18.5)*
Mean Rainfall	-0.24	0.36	-0.7	-1.73
	(-4.4)*	(7.6)*	(-3.4)*	(-7.6)*
Rainfall Var.	-0.009	0.07	-0.08	0.03
	(-2.9)*	(2.4)*	(-4.9)*	(-1.6)
Cotton Var.	0.003	-0.005	0.01	-0.03
	(1.2)	(-1.9)	(0.6)	(1.08)
Maize Var.	0.002	-0.0001	0.018	0.008
	(0.99)	(0.009)	(1.4)	(0.47)
Time	0.00006	0.00004	-0.00003	0.00008
	(-0.22)	(0.0017)	(-2.1)	(1.59)

Note: * denotes significance at 0.05 significance level

5.4.4 Model 2: Hypotheses Testing

The hypotheses have been tested under symmetry and no symmetry conditions for the input and expected yield share equations estimated as a linear system of equations. Symmetry, which is a necessary condition for cost minimisation is tested and was rejected using the Chi-square test, contrary to results obtained in model 1. Though this implies that farmers are not cost minimisers, the results indicates possible misspecification of the model.

The hypothesis of risk neutrality was also tested in this model by jointly testing whether weather and output variances are insignificant in the model. Risk neutrality was rejected using the Waldi-Chi square test. This hence implies that farmers are not risk neutral.

The hypothesis of the insignificance of weather variance is also tested using the chi-square test and is rejected at both the 99 per cent and 95 percent levels. This implies that weather variance is an important variable in the model and in explaining farmer behaviour. This variable is also used to test for farmers' risk preferences.

The hypothesis of insignificance of output variance is also tested and the null hypothesis is rejected. Therefore, farmers have responded to variability in output and have made decisions on this basis. The variable is also used to test for risk preferences.

The hypothesis of constant returns to scale is also tested and CRTS is not rejected. This is consistent with existing production theory.

When symmetry restrictions are imposed, the hypothesis of the insignificance of weather variance is tested and rejected at both the 99 per cent and 95 percent levels. This implies that weather variance is an important aspect in the analysis.

The hypothesis of insignificance of output variance was also tested jointly. However, in this case, the null hypothesis is not rejected. This implies that output variance is not important in farmer behaviour analysis. This result could also imply some model misspecifications.

The hypothesis of risk neutrality is also tested in this regression. It is rejected using the Chi- square distribution. This hence is consistent with the expected farmer behaviour.

The hypothesis of constant returns to scale is also tested and CRTS is not rejected at 5 percent significance level.

The Hicks neutral technical change is also tested. The results show that, the null hypothesis is not rejected at 5 percent level. This is contrary to the results obtained in model 1, and what would be expected.

From the above, it is therefore evident that small scale farmers are not risk neutral, and that technology has played a role in the production process. Also determined in this model is that the uncertainty about weather conditions influence production decisions. The table below shows the results of the hypotheses tested.

Table X: Model 2: Hypotheses Tested (Symmetry and No Symmetry)

	Symmetry		No Symmetry	
Test	X^2	Degrees of Freedom	X^2	Degrees of Freedom
1. Symmetry	---	--	328.21*	6
2. Insignificance of Weather Variance	26.71*	4	18.59*	4
3. Insignificance of Cotton Output Variance	14.12	4	16.04*	4
4. Insignificance of Maize Output Variance	10.68	4	19.32*	4
5. Constant Returns to Scale	1.05	2	0.49	2
6. Hicks Neutral Technical Change	0.08	2	0.42	2
7. Insignificance #2, #3 and #4 (Variances)	12.84	6	33.48*	6

Note: * denotes rejection of the null hypothesis at 0.05 significance level

5.4.5 Model 3: Non-Linear Estimation

Because of the existence of risk in the model, a non-linear estimation of the system of equations is done to capture and test for risk preferences in farmer's decision making process. The normalised cost share equations of inputs, expected yield, variances, were estimated together (13a-f) under both symmetry and no symmetry conditions.

When no symmetry conditions are imposed, the results show that most of the coefficients are significant. Seed and fertiliser are significant as was obtained in the first and second models. Labour has also been found to be significant in the output share equations. In this model most notable is the significance of the rainfall variance in the cotton yield share equation. The coefficient of risk aversion in both the variance share equations is significant.

The coefficients associated with the trend variable in both are positive and significant for the seed and fertiliser share equations, but have exhibited negative impacts on maize expected yield share equations.

When symmetry is imposed, the seed price is significant in the maize and cotton yield equations. The rainfall variance is also significant in the cotton output equation as obtained when symmetry is not imposed. Most notable in this model is the impact of technical change on seed, fertiliser, and yield share equations. the results indicate that, over time, there was an increasing expenditure levels on seed and fertiliser and consequently expected cotton and maize yield. The table below shows the results of the estimations of the equations.

Table XI: Model 3: Non-Linear Estimations, Input, Expected Yield and Variance Share Equations: (No Symmetry Conditions Imposed)

	SHARE EQUATIONS					
Variables	SEED	FERTILIZER	COTTON	MAIZE	COTTON VARIANCE	MAIZE VARIANCE
Seed Price	-0.9	-3.9	2.18	1.9	1.19	2.9
	(-0.59)	(-2.4)*	(2.41)*	(0.4)	(0.98)	[illegible]
Fert. Price	-2.8	-1.9	2.6	1.16	-3.9	4.2
	(-2.9)*	(-2.4)*	(2.8)*	(2.06)	(4.01)	[illegible]
Labour	3.41	2.00	5.7	1.5	4.01	2.01
	(2.46)*	(2.1)	(4.1)*	(0.21)	(3.28)*	
(1.001)						
Land	2.8	2.01	1.05	0.99	4.9	5.2
	(3.4)*	(3.2)*	(0.44)	(1.04)	(2.31)*	(3.41)*
Cotton Output	4.8	2.65	3.08	4.9	0.9	3.6
	(4.31)*	(2.9)*	(0.01)	(3.21)*	(2.1)	[illegible]
Maize Output	6.5	0.23	2.4	2.6	2.43	4.9
	(6.21)*	(1.35)	(1.41)	(2.6)*	(1.9)	(1.04)
Mean Rainfall	3.8	4.01	1.2	2.2	1.94	3.01
	(0.4)	(2.3)*	(3.1)*	(1.23)	(1.43)	(2.41)*
Rainfall Var.	0.7	0.45	2.4	2.9	2.02	0.06
	(2.3)*	(1.60)	(4.1)*	(1.43)	(1.41)	(1.03)
Cotton Var.	3.11	2.9	3.1	0.96	1.09	5.09
	(2.6)*	(1.43)	(0.01)	(0.97)	(2.04)*	(3.21)*
Maize Var.	2.2	1.96	4.01	5.4	2.1	0.31
	(1.9)	(1.99)	(4.1)*	5.5)*	(0.01)	(2.1)
CRA					0.002	0.07
					(3.25)*	(2.61)*
Time	2.3	2.14	0.42	0.95	0.02	0.02
	(4.01)*	(2.8)*	(0.54)	(1.4)	(0.021)	
(0.005)						

Note: * denotes significance at 0.05 significance level

Table XII: Model 3: Non-Linear Estimations, Input, Expected Yield and Variance Share Equations (Continued):(Symmetry Conditions Imposed)

	SHARE EQUATIONS					
Variables	SEED	FERT.	COTTON	MAIZE	COTTON VAR.	MAIZE VAR.
Seed Price	-6.04	-1.6	4.6	3.4	0.97	0.94
	(-2.4)*	(-1.16)	(5.0)*	(3.8)*	(0.008)	(0.41)
Fert. Price	-0.6	-1.02	1.58	0.8	0.9	0.89
	(-0.7)	(-1.003)	(1.7)	(0.9)	(2.1)	(0.009)
Labour	0.58	1.01	0.56	1.4	1.01	1.01
	(0.6)	(0.002)	(0.57)	(0.5)	(0.10)	(2.4*)
Land	2.8	2.01	1.05	0.99	4.9	5.2
	(3.4)*	(3.2)*	(0.44)	(1.04)	(2.31)*	(3.46)*
Cotton	4.8	2.65	3.08	4.9	0.9	3.6
	(4.31)*	(2.9)*	(0.01)	(3.21)*	(2.1)	(4.81)*
Maize	6.5	0.23	2.4	2.6	2.43	4.9
	(6.21)*	(1.35)	(1.41)	(2.6)*	(1.9)	(0.04)
Mean Rain	-1.004	0.9	1.7	0.7	0.98	0.98
	(-1.35)	(0.41)	(2.2)*	(0.8)	(2.4)*	(0.01)
Rainfall Var.	-0.11	2.19	-1.15	-0.6	1.02	1.2
	(-0.3)	(2.3)*	(-2.2)*	(-0.07)	(1.41)	(1.5)
Cotton Var.	3.11	2.9	3.1	0.96	1.09	5.09
	(2.6)*	(1.43)	(0.01)	(0.97)	(2.04)*	(3.21)*
Maize Var.	2.2	1.96	4.01	5.4	2.1	0.31
	(1.9)	(1.99)	(4.1)*	(5.5)*	(0.01)	(2.1)
CRA					0.02	0.09
					(0.001)	(-3.4)*
Time	0.9	2.2	1.13	1.4	1.2	0.5
	(8.6)*	(5.0)*	(12.2)*	(19.2)*	(1.3)	(0.004)

Note: * denotes significance at 0.05 significance level

5.4.6 Model 3: Hypotheses Testing

The hypotheses have been tested under symmetry and no symmetry conditions for the system of equations.

Given no symmetry restrictions, symmetry is tested and not rejected using Chi-square test. The likelihood ratio test with 6 degrees of freedom supports the chi-square test. Therefore in this model it is evident that the necessary conditions for cost minimisation have been met. The second order test has also been conducted. This test confirms cost minimisation. In this test, the second order derivatives for the inputs in the factor demands should be negative. That is the Hessian matrix should be negative semi-definite. The test confirms that the matrix is negative semi-definite.

The hypothesis of risk neutrality is also tested is rejected using the Waldi-Chi square test under symmetry and no symmetry conditions. The likelihood ratio test also rejected the null hypothesis. To determine whether farmers are risk preferrers or risk averse, the coefficient of risk aversion is further tested. Risk aversion implies that this coefficient be equal to one. This hypothesis is accepted at 10 percent significance level, but rejected at 5 percent level. We can therefore generalize that indeed farmers are risk averse. This hence is consistent with the expected farmer behaviour.

Risk neutrality is also tested to determine whether the variances of weather and yield are insignificant in the model. This is rejected for both the chi-square and likelihood ratio test. This further confirms farmers' risk preferences.

The hypothesis of the insignificance of weather variance is also tested and is rejected at both the 99 percent and 95 percent levels. The likelihood ratio test has also rejected the hypothesis. This implies that farmers have used the variability weather to determine what to produce and how much of inputs to allocate to a particular crop.

The hypothesis of insignificance of yield variance is also tested jointly and the null hypothesis is rejected for both the chi-square and the likelihood ratio test. This implies that output variance has also been an important aspect in farmers' decision making process. The table below shows the results of the hypotheses tested.

The hypothesis of constant returns to scale is also tested and CRTS was not rejected. This is consistent with existing production theory. The test for Hicks neutral technical change has been rejected in this model. Farmers have therefore responded to changes in technology.

The results above also hold when symmetry restrictions are imposed apriori.

From these results, it is evident that small scale farmers are not risk neutral, and that technology has played a role in the production process. Also determined in this model is that the uncertainty about weather conditions influence production decisions.

Table XIII: Model 3: Hypotheses Tested (Symmetry and No Symmetry) and Likelihood Ratio Tests

	Symmetry		No Symmetry			
Test	X^2	Degrees of Freedom	X^2	Degrees of Freedom	Likelihood Ratio Test (X^2)	Degrees of Freedom
1. Symmetry	-	-	8.43	15	0.18	6
2. Insignificance of Weather Variance	23.97*	6	68.08*	6	17.8*	6
3. Insignificance of Cotton Output Variance	-	-	23.98*	6	54.87*	6
4. Insignificance of Maize Output Variance	-	-	39.9*	6	45.43*	6
5. Constant Returns to Scale	1.37	2	27.01	2	0.25	6
6. Hicks Neutral Technical Change	115.9*	2	101.32*	2	43.87*	6
7. Insignificance of #2, #3 & #4 (Variances)	-	-	42.63*	6	33.72*	6
Risk Neutrality	65.8*	2	85.42*	6	75.60*	6

Note: * denotes rejection of the null hypothesis at 0.05 significance level

5.4.7 Model 4: Input Share Equations

In this model, normalised input share equations are estimated as a system of equations. These equations are tested under conditions of symmetry and no symmetry. However, the only differences between this model and model 1 is that in this model, only 1990 data was used for the fifteen farmers interviwed in each region. This therefore enabled the calculation of different variances for each year using the formular **(15b)**.

The results show that, the coefficients associated with the input prices are significant and negative. This implies that as input prices increase, the expenditure shares of these inputs reduce. This indicates a downward sloping demand curve. We can therefore, based on this result conclude that the observed decrease in yield can be explained by the reduction in input usage. This has resulted in low output levels and consequently lower gross margins.

Labour has also been found to be a significant factor. This is expected as small scale agriculture in Zambia is basically labour intensive.

Most significant in this model are the fertiliser and seed prices in the cotton and maize output share equations and as expected they have a positive effect on output.

Contrary to model 1, both cotton and maize yield variances have been found to be significant in this model. This implies that farmers have actually used the variability of their output to determine their production decision. This is contrary to the conclusion about the misspecification of the variance calculations done in the first model. The outcome of the variances is as what would be expected and this also potrays some responses towards risk and uncertainty. Table XIV shows the results obtained.

Table XIV: Model 4: Input Share Equations

	SHARE EQUATIONS			
	Symmetry		No Symmetry	
Variables	**SEED**	**FERTILIZER**	**SEED**	**FERTILIZER**
Seed Price	-3.75	-2.6	-1.2	-2.4
	(-6.3)*	(-4.5)*	(-6.7)*	(-5.3)*
Fert. Price	-3.6	-4.9	-2.7	-3.12
	(-3.8)*	(-5.5)*	(-4.5)*	(-5.33)*
Labour	-2.8	-2.34	-2.39	-2.89
	(-5.2)*	(-7.9)*	(1.17)	(-12.9)*
Land	1.89	4.43	0.17	0.38
	(3.5)*	(1.8)	(2.08)	(2.01)
Cotton Output	1.46	0.048	3.04	0.018
	(7.5)*	(2.09)	(8.7)*	(1.63)
Maize Output	4.34	1.53	4.13	3.19
	(2.53)	(2.09)	(5.08)*	(2.96)*
Mean Rainfall	-0.002	0.064	0.002	0.0068
	(-2.98)*	(2.061)	(3.25)*	(-1.6)
Rainfall Var.	-0.004	-0.005	-0.001	-0.008
	(-1.97)	(-2.32)	(-2.35)	(-1.6)
Cotton Var.	-0.004	-0.0032	-0.009	0.003
	(-4.82)*	(-2.83)*	(-3.3)*	(-1.3)
Maize Var.	0.13	-0.043	0.02	-0.02
	(3.34)*	(-2.86)*	(3.18)*	(-1.3)
Time	0.002	0.0003	0.0008	0.012
	(2.59)*	(2.57)*	(0.13)	(1.85)

Note: * denotes significance at 0.05 significance level

5.4.8 Model 4: Hypotheses Testing

The hypotheses have been tested under symmetry and no symmetry conditions for the input share equations estimated as a linear system of equations. Symmetry, which is a necessary condition for cost minimisation is tested and is not rejected using the Chi-square test at 5 percent significance level. This hence satisfies the necessary conditions for cost minimisation, and is in comformity with the results obtained in model 1.

The hypothesis of the insignificance of weather variance is also tested using the chi-square test and is rejected at 5 percent level of significance. This implies that weather variance is an important variable in the model and in explaining farmer behaviour. This variable is also used to test for farmers' risk preferences.

The hypotheses of insignificance of output variances for bot cotton and maize are also tested and the null hypotheses are rejected. This implies that farmers have responded to variability in yield, and this is contrary to the results obtained in model 1. This is so most probably because this model provides a better approximation of the variances of output.

The rejection of the test for Hicks neutral technical change in this model implies the existence of responses towards technical change. This is consistent with farmer's use of high yielding varieties of both cotton and maize. The hypothesis of constant returns to scale is also tested and CRTS is not rejected. This is consistent with existing production theory.

A weak test of the hypothesis of risk neutrality is also done by jointly testing whether weather and output variances are insignificant in the model. The test is rejected in both symmetry and no symmetry conditions at 5 percent significance level using the Waldi-Chi square test. This implies that farmers are not risk neutral.

Table XV:Model 4: Hypotheses tested

Test	Symmetry X^2	Symmetry Degrees of Freedom	No Symmetry X^2	No Symmetry Degrees of Freedom
1. Symmetry	**---**	**---**	**7.06**	**2**
2. Insignificance of Weather Variance	8.42*	2	5.67	2
3. Insignificance of Cotton Output Variance	7.64	2	5.13	2
4. Insignificance of Maize Output Variance	9.43*	2	7.35	2
5. Constant Returns to Scale	3.72	2	4.57	2
6. Hicks Neutral Technical Change	8.96*	2	11.22*	2
8. Insignificance of #2, #3, and #4	**7.95***	**2**	**6.17***	**2**

Note: * denotes rejection of the null hypothesis at 0.05 significance level

5.5 Summary of results

From the above three models, the following overall conclusions can be made:

1. Though not conclusively, the results indicate that input prices have reduced the expenditure shares of these inputs. This has affected yield potentials.
2. Labour is a significant factor in small scale agriculture in Zambia.
3. Small scale farmers in general are cost minimisers and rational producers. However, this requires more testing.
4. Small scale farmers in Zambia are risk averse.
5. Farmers have responded to variability crop yield.
6. Weather variance is an important factor in farmer decision making process.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1 Summary and Conclusion

This study initially tried to examine the following: to analyze the cotton subsector in Zambia; develop a conceptual model that would be used to empirically test farmer's risk preferences and input use; evaluate the following hypotheses; hypothesis of cost minimisation, risk neutrality, Hicks neutral technical change, significance of yield and weather variances; review government policy on small scale agriculture. Three models are constructed and hypotheses tested.

The most significant result from this study is that small scale farmers are cost minimisers and hence behave as any other rational producer. Also, these small scale farmers are not risk neutral and further testing showed that these farmers are risk averse. This implies that some factors have influenced farmer's risk preferences. These include, weather uncertainties and other production related factors. The test on significance of weather variance has proved that small scale farmers did consider weather to be a constraining factor, or a deciding factor in their decision making.

The empirical results show that there is a probable reduction in input expenditures by farmers. This is likely explained bythe decreasing profit margins for farmers which has led to the low application rates (below recommended levels) of the inputs, and consequently, low average yields.

Farmers lack adequate resources because the government has not let the market mechanism prevail in setting agricultural output prices. Government has set these prices much below the border prices, while agricultural input prices have continued to increase. If farmers are going to increase productivity, then government agricultural pricing policy should change.

Another reason for the farmers' lack of adequate financial resources is that small scale farmers do not have access to adequate agricultural credit. Commercial financial institutions have not been giving small scale farmers credit because they are perceived to be a bad risk. Government financial assistance has been inadequate for the same reason. This study has shown, through various tests that these farmers are not risk neutral and are indeed rational beings whose objective is to minimise their operating costs.

Since it has been identified that small scale farmers are not risk neutral, and that for their productivity to increase, they would need adequate financial resources, the government should ensure that the farmers do get the right price for their output. The situation would be improved if the output pricing system were completely liberalised and a method for providing collateral to small farmers was initiated. For instance, if farmers could obtain title deeds to the land they own under traditional ownership, they would have collateral to borrow from financial institutions. This would enable them even to hire the required amount of labour and be able to invest in more technical agricultural innovations like irrigation systems.

6.2 Recommendations on Policy change

Small scale agriculture in Zambia is a an important venture, and apart from supplying the country with food and other agricultural products, it is the main source of income in rural Zambia. It is for this reason that great importance should be given to these farmers, especially at a time when agriculture is the main alternative to mining. The following policy initiatives and changes are important to ensure growth and quality agriculture among small scale farmers:

i) rural financial institutions should be encouraged and created, either by the government, or local rural cooperatives.

ii) the government should examine means of creating collaterall for small scale farmers to encourage financial institutions to lend to this group;

iii) investment in rural areas should be a government priority.

6.3 Recommendations on Further Research

Because of research funding constraints, this study does not take into account the third region with a high concentration of cotton small scale farmers, who also produce maize. Therefore, any further study in this area should consider all the main cotton growing areas in the country.

This study does not have a large and representative sample size considering the number of small scale cotton farmers in the country. Therefore any research in this area should include as many small scale farmers as possible.

This study identifies some policy variables that could be of importance in modelling farmer behaviour given risk. Variables that are constraints should also be modelled in such a study. Such variables include credit constraints.

Other major constraints that have been identified by farmers themselves, should be considered for further study. These constraints do have major impacts on uncertainty in small scale agriculture. These constraints include, payment time, input delivery and marketing and storage of crops. Therefore any further research in the sector should consider these constraints.

6.4 Limitations of the study

6.4.1 Study Area

This study, like many others has a number of limitations. The data used in the analysis is from farmers in two cotton growing area. The survey was not done in one of the major cotton growing area as such the, results may not completely reflect the same farmer responses in the whole country.

6.4.2 Data

Also the study has not been able to take into account physical capital inputs. This was not possible because it is difficult to quantify such input in small scale agriculture. Apart from this, the data used for rainfall is not on-farm data, therefore farmer responses to weather variation cannot be completely represented by the data used.

6.4.2 Data

Also the study has not been able to take into account physical capital inputs. This was not possible because it is difficult to quantify such input in small scale agriculture. Apart from this, the data used for rainfall is not on-farm data, therefore farmer responses to weather variation cannot be completely represented by the data used.

Due to lack of time series output data, the calculation of the variances of output could be highly biased.

6.4.3 Model Specification

The study does not incorporate the constraint policy variables that have been identified, in the model, notably, credit. Also the model assumes a mean variance utility function, which is restrictive when modelling farmer responses. Therefore, because of the nature of the model, the obtained results could be highly biased.

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APPENDIX A: FARMER QUESTIONNAIRE

UNIVERSITY OF MANITOBA

DEPARTMENT OF AGRICULTURAL ECONOMICS

WINNIPEG, MANITOBA

CANADA

DISTRICT...................... PROVINCE.................

1. **NAME**............................ 2. **AGE**...........

3. **MARITAL STATUS** 4. **NUMBER OF WIVES** ....

Married	
Single	
Divorced	
Widowed	

5. **NUMBER OF CHILDREN**

Boys	No	Girls	No.
<2yrs		< 2yrs	
3-7yrs		3-7yrs	
>7yrs		> 7yrs	

6. **NUMBER OF OTHER FAMILY MEMBERS**

Boys	No	Girls	No.
<2yrs		< 2yrs	
3-7yrs		3-7yrs	
>7yrs		> 7yrs	

7. **LEVEL OF EDUCATION FOR HEAD OF THE FAMILY**

(Please tick in one box)

None	
Primary	
Secondary	
College	

B: **AGRICULTURAL PRODUCTION AND INPUT USE**

1. TOTAL AREA AVAILABLE FOR AGRICULTURE ....ha

2. MAIN CROPS GROWN................................

3. CROP PRODUCTION AND AREA(1985-1990)

i). Total Crop Production (in kgs)

CROP	1985	1986	1987	1988	1989	1990

ii). Total Crop Area (in Hectarages)

CROP	1985	1986	1987	1988	1989	1990

4. TOTAL INPUT USE

INPUTS	1985	1986	1987	1988	1989	1990
Seed (kgs)						
Fertiliser (kgs)						
Chemicals (lts)						
Labour(persons)						

5. INPUT USE BY CROP

i). Maize

INPUTS	1985	1986	1987	1988	1989	1990
Seed (kgs)						
Fertiliser (kgs)						
Chemicals (lts)						
Labour(persons)						

ii). Cotton

INPUTS	1985	1986	1987	1988	1989	1990
Seed (kgs)						
Fertiliser (kgs)						
Chemicals (lts)						
Labour(persons)						

6. HOW MANY DAYS IN A WEEK DO YOU WORK ON YOUR PLOT?........

7. AT WHAT TIME DO YOU START TO WORK IN YOUR PLOT?.......AND AT WHAT TIME DO YOU USUALLY STOP?.........

8. HOW MANY DAYS DO YOU APPROXIMATELY SPEND ON THE FOLLOWING ACTIVITIES:
   A. PLANTING.........
   B. WEEDING AND THINNING.........
   C. SPRAYING.......
   D. HARVESTING.....

9. WHY DO YOU GROW THESE CROPS?
....
....

10. WHERE DO YOU SELL YOUR PRODUCTS?
....

11. HOW DO YOU TRANSPORT YOUR PRODUCTS FROM THE FARM TO YOUR POINT OF SALE?
....
....

12. ARE THE FARM INPUTS READILY AVAILABLE WHEN YOU NEED THEM? IF
NOT, WOULD YOU KNOW WHY?
....

13. WHO SUPPLIES YOU WITH THE AGRICULTURAL INPUTS ?
....
....

14. HAVE YOU EVER OBTAINED A LOAN FROM A BANK TO FINANCE YOUR AGRICULTURE? .... IF YES, HOW OFTEN? ....

IF NO, WHY NOT? ....

15. WHAT TYPE OF HELP ARE YOU RECEIVING FROM THE GOVERNMENT ?
....

16. IN YOUR OPINION, WHAT WOULD YOU LIKE TO SEE CHANGE IN AGRICULTURAL POLICY?......................................
....

17. WHAT ARE THE MAIN PROBLEMS YOU ARE FACING ?
....
....

APPENDIX B: DATA CATEGORIES

Data Categories: Central Province

Appendix 2A: Cotton Production Variables

Farmer	Year	Hectarage	Seed (kgs)	Chemicals (lts)	Labour (hours)	Seed Price in ZK/kg
1	1985	3	72	16	500	15.00
	1986	5	72	16	600	18.50
	1987	3	48	12	400	20.00
	1988	4	48	12	580	29.25
	1989	5	36	8	300	54.00
	1990	6	48	12	460	76.50
2	1985	5	48	12	400	15.00
	1986	5	73	18	600	18.50
	1987	4	72	16	480	20.00
	1988	3	72	16	500	29.25
	1989	4	48	12	400	54.00
	1990	6	72	12	500	76.50
3	1985	3	26	8	300	15.00
	1986	5	51	12	400	18.50
	1987	6	51	12	400	20.00
	1988	5	72	15	540	29.25
	1989	4	26	8	340	54.00
	1990	3	72	12	500	76.50
4	1985	4	54	12	390	15.00
	1986	4	30	8	300	18.50
	1987	6	54	12	400	20.00
	1988	4	54	12	300	29.25
	1989	4	54	12	340	54.00
	1990	6	54	12	480	76.50
5	1985	4	74	16	390	15.00
	1986	3	54	12	350	18.50
	1987	6	54	12	500	20.00
	1988	4	74	16	400	29.25
	1989	4	74	16	360	54.00
	1990	4	54	12	380	76.50

Appendix 2A: Cotton Production Variables (Continued)

Farmer	Year	Hectarage	Seed (kgs)	Chemicals (lts)	Labour (hours)	Seed Price in ZK/kg
6	1985	5	76	16	500	15.00
	1986	4	51	12	400	18.50
	1987	5	75	20	590	20.00
	1988	4	51	12	400	29.25
	1989	4	75	20	500	54.00
	1990	5	75	20	510	76.50
7	1985	5	96	24	580	15.00
	1986	5	76	16	500	18.50
	1987	6	96	24	720	20.00
	1988	4	51	12	400	29.25
	1989	5	96	24	500	54.00
	1990	5	76	16	510	76.50
8	1985	6	75	20	550	15.00
	1986	5	73	18	500	18.50
	1987	4	75	20	400	20.00
	1988	6	74	16	502	29.25
	1989	6	75	20	520	54.00
	1990	5	30	8	400	76.50
9	1985	5	72	16	480	15.00
	1986	4	100	20	400	18.50
	1987	5	80	16	410	20.00
	1988	6	100	20	550	29.25
	1989	5	80	16	480	54.00
	1990	4	60	12	360	76.50
10	1985	4	60	12	400	15.00
	1986	4	120	24	400	18.50
	1987	6	60	12	550	20.00
	1988	5	120	24	500	29.25
	1989	4	100	20	400	54.00
	1990	4	60	12	350	76.50

Appendix 2A: Cotton Production Variables (Continued)

Farmer	Year	Hectarage	Seed (kgs)	Chemicals (lts)	Labour (hours)	Seed Price in ZK/kg
11	1985	5	60	16	500	15.00
	1986	4	80	16	490	18.50
	1987	7	100	20	560	20.00
	1988	5	80	16	500	29.25
	1989	5	120	24	800	54.00
	1990	5	34	16	400	76.50
12	1985	6	100	24	600	15.00
	1986	5	80	16	480	18.50
	1987	4	100	20	600	20.00
	1988	4	100	20	600	29.25
	1989	5	80	24	500	54.00
	1990	5	60	20	600	76.50
13	1985	6	120	12	360	15.00
	1986	5	100	24	720	18.50
	1987	4	90	12	360	20.00
	1988	4	80	20	530	29.25
	1989	5	90	16	500	54.00
	1990	3	65	16	502	76.50
14	1985	3	70	8	300	15.00
	1986	4	90	20	600	18.50
	1987	3	65	8	400	20.00
	1988	5	120	16	480	29.25
	1989	4	80	12	360	54.00
	1990	4	95	20	600	76.50
15	1985	4	80	4	500	15.00
	1986	3	80	16	480	18.50
	1987	3	60	8	300	20.00
	1988	3	60	12	406	29.25
	1989	4	75	12	400	54.00
	1990	4	80	12	500	76.50

Appendix 2A: Cotton Production Variables (Continued)

Farmer	Year	Chemical Price in ZK/lt	Output Price in ZK/kg	Output Qty(kgs)	CPI	Mean Rainfall (in mm)
1	1985	43.75	0.99	2,400	145.65	1,121
	1986	62.00	1.90	2,000	182.61	962
	1987	120.00	3.00	300	347.83	845
	1988	178.00	3.60	1,440	652.17	1,291
	1989	372.00	3.60	700	782.61	1,121
	1990	548.00	9.70	1,200	956.87	1,225
2	1985	43.75	0.99	1,800	145.65	1,121
	1986	62.00	1.90	2,250	182.61	962
	1987	120.00	3.00	400	347.83	845
	1988	178.00	3.60	1,920	652.17	1,291
	1989	372.00	3.60	1,050	782.61	1,121
	1990	548.00	9.70	1,600	956.87	1,225
3	1985	43.75	0.99	1,200	145.65	1,121
	1986	62.00	1.90	1,500	182.61	962
	1987	120.00	3.00	300	347.83	845
	1988	178.00	3.60	1,920	652.17	1,291
	1989	372.00	3.60	700	782.61	1,121
	1990	548.00	9.70	1,600	956.87	1,225
4	1985	43.75	0.99	1,800	145.65	1,121
	1986	62.00	1.90	1,000	182.61	962
	1987	120.00	3.00	300	347.83	845
	1988	178.00	3.60	1,440	652.17	1,291
	1989	372.00	3.60	1,050	782.61	1,121
	1990	548.00	9.70	1,200	956.87	1,225
5	1985	43.75	0.99	2,400	145.65	1,121
	1986	62.00	1.90	1,500	182.61	962
	1987	120.00	3.00	300	347.83	845
	1988	178.00	3.60	1,920	652.17	1,291
	1989	372.00	3.60	1,400	782.61	1,121
	1990	548.00	9.70	1,200	956.87	1,225

Appendix 2A: Cotton Production Variables (Continued)

Farmer	Year	Chemical Price in ZK/lt	Output Price in ZK/kg	Output Qty(kgs)	CPI	Mean Rainfall (in mm)
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	1987	120.00	3.00	500	347.83	845
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	1989	372.00	3.60	1,750	782.61	1,121
	1990	548.00	9.70	2,000	956.87	1,225
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	1986	62.00	1.90	1,750	182.61	962
	1987	120.00	3.00	600	347.83	845
	1988	178.00	3.60	1,440	652.17	1,291
	1989	372.00	3.60	2,100	782.61	1,121
	1990	548.00	9.70	1,600	956.87	1,225
8	1985	43.75	0.99	3,000	145.65	1,121
	1986	62.00	1.90	2,250	182.61	962
	1987	120.00	3.00	500	347.83	845
	1988	178.00	3.60	1,920	652.17	1,291
	1989	372.00	3.60	1,750	782.61	1,121
	1990	548.00	9.70	800	956.87	1,225
9	1985	43.75	0.99	2,400	145.65	1,121
	1986	62.00	1.90	2,500	182.61	962
	1987	120.00	3.00	400	347.83	845
	1988	178.00	3.60	2,400	652.17	1,291
	1989	372.00	3.60	1,400	782.61	1,121
	1990	548.00	9.70	1,200	956.87	1,225
10	1985	43.75	0.99	1,800	145.65	1,121
	1986	62.00	1.90	3,000	182.61	962
	1987	120.00	3.00	300	347.83	845
	1988	178.00	3.60	2,880	652.17	1,291
	1989	372.00	3.60	1,750	782.61	1,121
	1990	548.00	9.70	1,200	956.87	1,225

Appendix 2A: Cotton Production Variables (Continued)

Farmer	Year	Chemical Price in ZK/lt	Output Price in ZK/kg	Output Qty(kgs)	CPI	Mean Rainfall (in mm)
11	1985	43.75	0.99	2,400	145.65	1,121
	1986	62.00	1.90	2,000	182.61	962
	1987	120.00	3.00	500	347.83	845
	1988	178.00	3.60	1,920	652.17	1,291
	1989	372.00	3.60	2,100	782.61	1,121
	1990	548.00	9.70	1,600	956.87	1,225
12	1985	43.75	0.99	3,600	145.65	1,121
	1986	62.00	1.90	2,000	182.61	962
	1987	120.00	3.00	500	347.83	845
	1988	178.00	3.60	2,400	652.17	1,291
	1989	372.00	3.60	2,100	782.61	1,121
	1990	548.00	9.70	2,000	956.87	1,225
13	1985	43.75	0.99	1,800	145.65	1,121
	1986	62.00	1.90	3,000	182.61	962
	1987	120.00	3.00	300	347.83	845
	1988	178.00	3.60	2,400	652.17	1,291
	1989	372.00	3.60	1,400	782.61	1,121
	1990	548.00	9.70	1,600	956.87	1,225
14	1985	43.75	0.99	1,200	145.65	1,121
	1986	62.00	1.90	2,500	182.61	962
	1987	120.00	3.00	200	347.83	845
	1988	178.00	3.60	1,920	652.17	1,291
	1989	372.00	3.60	1,050	782.61	1,121
	1990	548.00	9.70	2,000	956.87	1,225
15	1985	43.75	0.99	600	145.65	1,121
	1986	62.00	1.90	2,000	182.61	962
	1987	120.00	3.00	200	347.83	845
	1988	178.00	3.60	1,440	652.17	1,291
	1989	372.00	3.60	1,050	782.61	1,121
	1990	548.00	9.70	1,200	956.87	1,225

Data Categories: Southern Province (Mumbwa District)

Appendix 2A: Cotton Production Variables

Farmer	Year	Hectarage	Seed (kgs)	Chemicals (lts)	Labour (hours)	Seed Price in ZK/kg
1	1985	4	72	16	480	15.00
	1986	4	72	16	480	18.50
	1987	3	48	12	360	20.00
	1988	3	48	12	360	29.25
	1989	2	36	8	240	54.00
	1990	3	48	12	360	76.50
2	1985	3	48	12	360	15.00
	1986	4	73	18	540	18.50
	1987	4	72	16	480	20.00
	1988	4	72	16	480	29.25
	1989	3	48	12	360	54.00
	1990	4	72	12	480	76.50
3	1985	2	26	8	240	15.00
	1986	3	51	12	360	18.50
	1987	3	51	12	360	20.00
	1988	4	72	15	480	29.25
	1989	2	26	8	240	54.00
	1990	4	72	12	480	76.50
4	1985	3	54	12	360	15.00
	1986	2	30	8	240	18.50
	1987	3	54	12	360	20.00
	1988	3	54	12	360	29.25
	1989	3	54	12	360	54.00
	1990	3	54	12	360	76.50
5	1985	4	74	16	480	15.00
	1986	3	54	12	360	18.50
	1987	3	54	12	360	20.00
	1988	4	74	16	480	29.25
	1989	4	74	16	360	54.00
	1990	3	54	12	360	76.50

Appendix 2A: Cotton Production Variables (Continued)

Farmer	Year	Hectarage	Seed (kgs)	Chemicals (lts)	Labour (hours)	Seed Price in ZK/kg
6	1985	4	76	16	480	15.00
	1986	3	51	12	360	18.50
	1987	5	75	20	600	20.00
	1988	3	51	12	360	29.25
	1989	5	75	20	600	54.00
	1990	5	75	20	600	76.50
7	1985	6	96	24	720	15.00
	1986	4	76	16	480	18.50
	1987	6	96	24	720	20.00
	1988	3	51	12	360	29.25
	1989	6	96	24	720	54.00
	1990	4	76	16	480	76.50
8	1985	5	75	20	600	15.00
	1986	4	73	18	540	18.50
	1987	5	75	20	600	20.00
	1988	4	74	16	480	29.25
	1989	5	75	20	600	54.00
	1990	2	30	8	240	76.50
9	1985	4	72	16	480	15.00
	1986	5	100	20	600	18.50
	1987	4	80	16	480	20.00
	1988	5	100	20	600	29.25
	1989	4	80	16	480	54.00
	1990	3	60	12	360	76.50
10	1985	3	60	12	360	15.00
	1986	6	120	24	720	18.50
	1987	3	60	12	360	20.00
	1988	6	120	24	720	29.25
	1989	5	100	20	600	54.00
	1990	3	60	12	350	76.50

Appendix 2A: Cotton Production Variables (Continued)

Farmer	Year	Hectarage	Seed (kgs)	Chemicals (lts)	Labour (hours)	Seed Price in ZK/kg
11	1985	4	80	16	480	15.00
	1986	4	80	16	480	18.50
	1987	5	100	20	600	20.00
	1988	4	80	16	480	29.25
	1989	6	120	24	720	54.00
	1990	4	80	16	480	76.50
12	1985	6	120	24	720	15.00
	1986	4	80	16	480	18.50
	1987	5	100	20	600	20.00
	1988	5	100	20	600	29.25
	1989	6	120	24	720	54.00
	1990	5	100	20	600	76.50
13	1985	3	60	12	360	15.00
	1986	6	120	24	720	18.50
	1987	3	60	12	360	20.00
	1988	5	100	20	600	29.25
	1989	4	80	16	480	54.00
	1990	4	80	16	480	76.50
14	1985	2	40	8	240	15.00
	1986	5	100	20	600	18.50
	1987	2	40	8	240	20.00
	1988	4	80	16	480	29.25
	1989	3	60	12	360	54.00
	1990	5	100	20	600	76.50
15	1985	1	20	4	120	15.00
	1986	4	80	16	480	18.50
	1987	2	40	8	240	20.00
	1988	3	60	12	360	29.25
	1989	3	60	12	360	54.00
	1990	3	60	12	360	76.50

Appendix 2B: Maize Production Variables (Continued)

Farmer	Year	Fert. Price in ZK/kg	Output Price in ZK/kg	Output Qty(kgs)	CPI	Labour Cost/hr
1	1985	0.53	0.32	3,240	145.65	4.21
	1986	1.36	0.61	11,160	182.61	6.50
	1987	1.36	0.87	2,430	347.83	8.00
	1988	1.62	0.89	2,340	652.17	9.20
	1989	7.79	1.20	2,340	782.61	28.50
	1990	10.01	3.16	5,400	956.87	38.00
2	1985	0.53	0.32	5,040	145.65	4.21
	1986	1.36	0.61	3,240	182.61	6.50
	1987	1.36	0.87	8,370	347.83	8.00
	1988	1.62	0.89	3,240	652.17	9.20
	1989	7.79	1.20	3,510	782.61	28.50
	1990	10.01	3.16	4,320	956.87	38.00
3	1985	0.53	0.32	5,040	145.65	4.21
	1986	1.36	0.61	4,320	182.61	6.50
	1987	1.36	0.87	11,160	347.83	8.00
	1988	1.62	0.89	2,430	652.17	9.20
	1989	7.79	1.20	4,680	782.61	28.50
	1990	10.01	3.16	5,400	956.87	38.00
4	1985	0.53	0.32	3,240	145.65	4.21
	1986	1.36	0.61	8,370	182.61	6.50
	1987	1.36	0.87	3,240	347.83	8.00
	1988	1.62	0.89	3,610	652.17	9.20
	1989	7.79	1.20	4,320	782.61	28.50
	1990	10.01	3.16	5,040	956.87	38.00
5	1985	0.53	0.32	3,240	145.65	4.21
	1986	1.36	0.61	8,370	182.61	6.50
	1987	1.36	0.87	3,240	347.83	8.00
	1988	1.62	0.89	1,920	652.17	9.20
	1989	7.79	1.20	3,610	782.61	28.50
	1990	10.01	3.16	4,320	956.87	38.00

Appendix 2B: Maize Production Variables (Continued)

Farmer	Year	Fert. Price in ZK/kg	Output Price in ZK/kg	Output Qty(kgs)	CPI	Labour Cost/hr
6	1985	0.53	0.32	7,560	145.65	4.21
	1986	1.36	0.61	4,320	182.61	6.50
	1987	1.36	0.87	11,160	347.83	8.00
	1988	1.62	0.89	2,430	652.17	9.20
	1989	7.79	1.20	4,680	782.61	28.50
	1990	10.01	3.16	3,240	956.87	38.00
7	1985	0.53	0.32	3,780	145.65	4.21
	1986	1.36	0.61	3,240	182.61	6.50
	1987	1.36	0.87	8,370	347.83	8.00
	1988	1.62	0.89	3,240	652.17	9.20
	1989	7.79	1.20	4,680	782.61	28.50
	1990	10.01	3.16	3,780	956.87	38.00
8	1985	0.53	0.32	3,240	145.65	4.21
	1986	1.36	0.61	5,580	182.61	6.50
	1987	1.36	0.87	3,240	347.83	8.00
	1988	1.62	0.89	4,680	652.17	9.20
	1989	7.79	1.20	2,160	782.61	28.50
	1990	10.01	3.16	7,560	956.87	38.00
9	1985	0.53	0.32	4,320	145.65	4.21
	1986	1.36	0.61	8,370	182.61	6.50
	1987	1.36	0.87	3,240	347.83	8.00
	1988	1.62	0.89	4,680	652.17	9.20
	1989	7.79	1.20	3,240	782.61	28.50
	1990	10.01	3.16	5,040	956.87	38.00
10	1985	0.53	0.32	4,320	145.65	4.21
	1986	1.36	0.61	11,160	182.61	6.50
	1987	1.36	0.87	4,050	347.83	8.00
	1988	1.62	0.89	3,510	652.17	9.20
	1989	7.79	1.20	3,240	782.61	28.50
	1990	10.01	3.16	5,040	956.87	38.00

Appendix 2B: Maize Production Variables (Continued)

Farmer	Year	Fert. Price in ZK/kg	Output Price in ZK/kg	Output Qty(kgs)	CPI	Labour Cost/hr
11	1985	0.53	0.32	3,240	145.65	4.21
	1986	1.36	0.61	11,160	182.61	6.50
	1987	1.36	0.87	3,240	347.83	8.00
	1988	1.62	0.89	3,510	652.17	9.20
	1989	7.79	1.20	2,160	782.61	28.50
	1990	10.01	3.16	6,300	956.87	38.00
12	1985	0.53	0.32	3,240	145.65	4.21
	1986	1.36	0.61	8,370	182.61	6.50
	1987	1.36	0.87	2,430	347.83	8.00
	1988	1.62	0.89	4,680	652.17	9.20
	1989	7.79	1.20	2,160	782.61	28.50
	1990	10.01	3.16	3,780	956.87	38.00
13	1985	0.53	0.32	2,160	145.65	4.21
	1986	1.36	0.61	8,370	182.61	6.50
	1987	1.36	0.87	3,240	347.83	8.00
	1988	1.62	0.89	3,510	652.17	9.20
	1989	7.79	1.20	5,400	782.61	28.50
	1990	10.01	3.16	3,780	956.87	38.00
14	1985	0.53	0.32	2,160	145.65	4.21
	1986	1.36	0.61	5,580	182.61	6.50
	1987	1.36	0.87	2,430	347.83	8.00
	1988	1.62	0.89	4,680	652.17	9.20
	1989	7.79	1.20	5,400	782.61	28.50
	1990	10.01	3.16	5,040	956.87	38.00
15	1985	0.53	0.31	2,160	145.65	4.21
	1986	1.36	0.61	11,160	182.61	6.50
	1987	1.36	0.87	2,430	347.83	8.00
	1988	1.62	0.89	4,580	652.17	9.20
	1989	7.79	1.20	4,320	782.61	28.50
	1990	10.01	3.16	6,300	956.87	38.00

Data Categories: Southern Province (Mumbwa District)

Appendix 2B: Maize Production Variables

Farmer	Year	Hectarage	Seed (kgs)	Fertiliser (kgs)	Labour (hours)	Seed Price in ZK/kg
1	1985	3	48	180	240	1.64
	1986	4	52	300	320	2.52
	1987	3	48	210	240	3.66
	1988	2	30	200	160	6.36
	1989	5	90	300	400	11.86
	1990	4	52	380	320	20.86
2	1985	3	48	240	240	1.64
	1986	3	48	220	240	2.52
	1987	4	52	380	320	3.66
	1988	3	54	300	240	6.36
	1989	4	52	360	320	11.86
	1990	4	52	400	320	20.86
3	1985	4	52	270	320	1.64
	1986	4	52	300	320	2.52
	1987	3	48	300	240	3.66
	1988	5	72	400	320	6.36
	1989	5	90	500	400	11.86
	1990	3	48	300	240	20.86
4	1985	3	48	210	240	1.64
	1986	3	48	270	240	2.52
	1987	4	52	320	320	3.66
	1988	3	48	300	240	6.36
	1989	4	52	360	320	11.86
	1990	4	52	400	320	20.86
5	1985	3	48	300	240	1.64
	1986	3	48	300	240	2.52
	1987	4	52	360	320	3.66
	1988	3	48	270	240	6.36
	1989	4	52	400	320	11.86
	1990	6	84	510	480	20.86

Appendix 2B: Maize Production Variables (Continued)

Farmer	Year	Hectarage	Seed (kgs)	Fertiliser (kgs)	Labour (hours)	Seed Price in ZK/kg
6	1985	4	52	280	320	1.64
	1986	4	52	320	320	2.52
	1987	3	48	270	240	3.66
	1988	4	52	300	320	6.36
	1989	3	48	270	240	11.86
	1990	3	48	270	240	20.86
7	1985	3	48	300	240	1.64
	1986	3	48	300	240	2.52
	1987	4	52	400	320	3.66
	1988	4	52	400	320	6.36
	1989	3	48	300	240	11.86
	1990	3	48	300	240	20.86
8	1985	3	48	300	240	1.64
	1986	2	30	200	160	2.52
	1987	4	52	400	320	3.66
	1988	4	52	400	320	6.36
	1989	2	30	200	160	11.86
	1990	6	84	500	480	20.86
9	1985	4	52	270	320	1.64
	1986	3	48	300	240	2.52
	1987	4	52	270	320	3.66
	1988	4	52	270	320	6.36
	1989	3	48	300	240	11.86
	1990	4	52	280	320	20.86
10	1985	4	52	300	320	1.64
	1986	4	52	300	320	2.52
	1987	5	90	400	400	3.66
	1988	3	48	200	240	6.36
	1989	3	48	200	240	11.86
	1990	4	52	300	320	20.86

Appendix 2B: Maize Production Variables (Continued)

Farmer	Year	Hectarage	Seed (kgs)	Fertiliser (kgs)	Labour (hours)	Seed Price in ZK/kg
11	1985	3	48	300	240	1.64
	1986	4	52	400	320	2.52
	1987	4	52	400	320	3.66
	1988	3	48	300	240	6.36
	1989	2	30	200	160	11.86
	1990	5	90	500	400	20.86
12	1985	3	48	210	240	1.64
	1986	3	48	230	240	2.52
	1987	3	48	240	240	3.66
	1988	4	52	370	320	6.36
	1989	2	30	200	160	11.86
	1990	3	48	270	240	20.86
13	1985	2	30	200	160	1.64
	1986	3	48	300	240	2.52
	1987	4	52	400	320	3.66
	1988	3	48	300	240	6.36
	1989	5	90	470	400	11.86
	1990	3	30	200	240	20.86
14	1985	2	30	200	160	1.64
	1986	2	48	280	160	2.52
	1987	3	54	300	240	3.66
	1988	4	52	360	320	6.36
	1989	5	90	420	400	11.86
	1990	4	52	360	320	20.86
15	1985	2	30	200	160	1.64
	1986	4	52	400	320	2.52
	1987	3	48	300	240	3.66
	1988	4	52	400	320	6.36
	1989	4	52	400	320	11.86
	1990	5	90	500	400	20.86