RELATIVE ECONOMIC EFFICIENCY OF EMERGENT AND COMMERCIAL MAIZE FARMS IN ZAMBIA

by

FAUSTIN MWAPE

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DEDICATION

To my late father, Mr. M. Musonda, my mother, Ms. N. Kabwe, and my family.

ABSTRACT

RELATIVE ECONOMIC EFFICIENCY OF EMERGENT AND COMMERCIAL MAIZE FARMS IN ZAMBIA

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The staple food of Zambia is maize. Since maize is produced by subsistence, emergent, and commercial farms, there is debate about the proper policy to increase maize production. This study compares economic, price and technical efficiencies of emergent and commercial farms, and also tests for the existence of constant returns to scale. Using 1985/86 cross section farm data and Zellner's method, profit and variable input demand functions were jointly estimated.

There is no significant difference in the economic efficiency of the two farm groups. Based on the ranking technique, emergent farms are relatively more price-efficient. Thus, it is possible to infer that commercial farms are relatively more technical-efficient. In addition, the two farm groups operate under constant returns to scale.

If more resources are allocated to emergent farms, there is a statistically insignificant gain (22%) in economic efficiency. The superior price efficiency of emergent farms may be due to careful management employed to ensure food supply. Commercial farm technical efficiency advantage may be attributed to access to inputs needed to exploit the

potential of maize hybrids. Constant returns to scale imply that efficient farms could occur in a wide range of sizes. As for policies to raise production, a 10% increase of hired labor, fertilizer or other cash inputs would raise maize supply and profit by 0.27%, 3.10%, or 1.80%, respectively. In the long run, a 10% increase in family labor, non-land capital or harvested area would raise maize supply by 1.86%, 0.61%, or 4.6%, respectively. Even though area expansion appears attractive, foreign exchange constraints could limit this policy, thus intensive use of small areas is the feasible option. Therefore, emergent farms could be encouraged to increase maize production based on economic efficiency, equity and proportion of domestic resource use arguments.

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I am indebted to my: late father, mother, brothers and sisters for their support and understanding. I thank all my friends and relatives for the support I continue to enjoy.

Finally, the task was greatly facilitated by the love and secretarial assistance of my wife, Maureen, and the love of my sons, Kabwe and Chanda. I thank them for their support, patience, and encouragement.

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Chapter I

INTRODUCTION

Zambia, like many developing countries, has focused on raising agricultural production. The apparent shift of emphasis from copper to agriculture is due to: (1) the relatively lower world copper prices since 1975; (2) concern for more than two thirds (Dinham and Hines [1983]) of the population engaged in agriculture; (3) rising food imports; and (4) significant differences in productivity among farmers.[1]

Zambia has potential to grow many crops. At the moment, only a few crops are produced in significant proportions. Figure 1 indicates that maize accounted for 78 percent of the value of crop production, thus it the most important crop. The World Bank [1984a, p.78] reported that maize accounts for 99 percent of all marketed major food crops in Zambia. Jansen [1986] found that marketed maize comes from emergent (60%) and commercial (40%) farmers.

In addition, Figure 1 indicates that Zambia produces cotton, sunflower, soybeans, groundnuts, virginia tobacco and small amounts of other crops. Most of these crops are produced as cash crops. Except for tobacco, most of the other crops are relatively new and have not been given the attention maize receives. As the government seeks to expand agricultural exports, these crops are getting increasing attention in the form of research and economic incentives.

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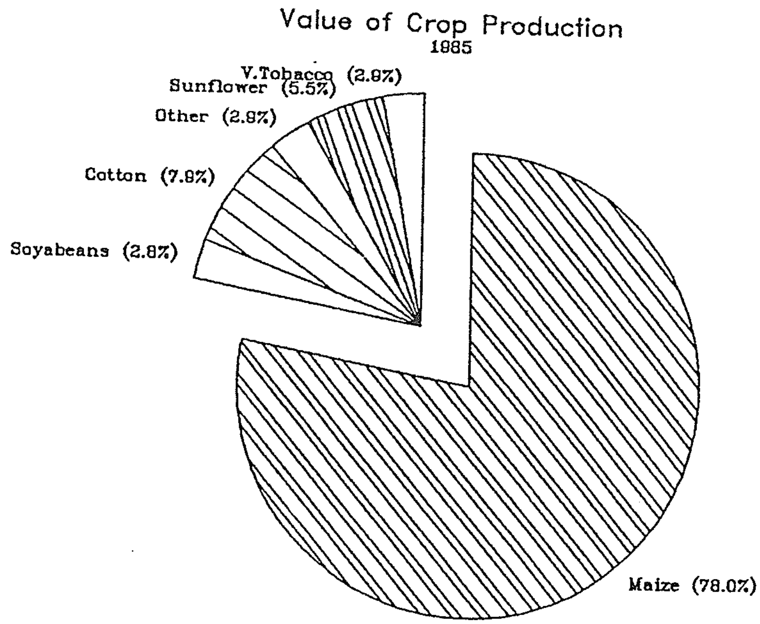
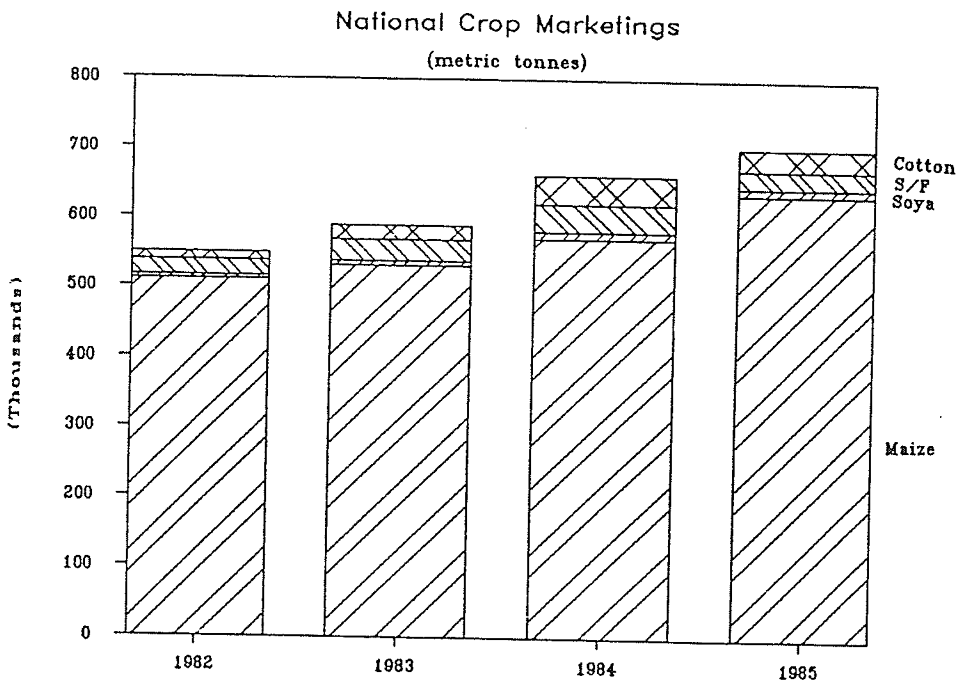
[1] Differences in productivity suggested that there is potential for increased agricultural production.

Figure 1: Proportions of Crop Production and Marketings in Zambia





Source: Ministry of Agriculture and Water Development, "Agricultural Statistics Bulletin," December, 1985, p.8.

The Ministry of Agriculture and Water Development (MAWD) acknowledges the existence of three farm groups; namely subsistence, emergent, and commercial. The broad characteristics of these groups are identified in Table 1. Most subsistence farmers do not use purchased inputs because of lack of regular cash income, irregular supply of inputs, and inappropriate technology.[2] Using family labor and basic tools, they meet family needs and rarely produce a marketable surplus. Emergent farmers are guided by subsistence and market goals. They use oxen and a few purchased inputs. On the basis of levels of management, Jansen [1986] divided commercial farmers into semi-commercial (about 5300) and large (about 700) farmers. Depending on the farm size, they use oxen and/or tractors. An important observation is that maize is grown by all farm groups for food and/or cash.

In the 1960s and early 1970s commercial farmers supplied most of the marketed agricultural products; utilized about 90 percent of agricultural credit; and farmed in Central and Southern Provinces of Zambia where good agricultural land and transport are conducive to farming (Figure 2, p.10). Dodge [1977] attributed the favorable position of commercial farmers to colonial government policies (1890 - 1964), i.e., commercial farmers were encouraged to generate a surplus. After independence (1964), general pronouncements centered on encouraging small scale and emergent farmers. However, the government did not provide appropriate technology and often delivered essential services late. In an attempt

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[2] As discussed in Chapter II, section 2.5.4 (p.29), some hybrids of maize require planting at the beginning of the rain season. Because many small scale farms cannot plough during the dry season (due to dependence on the hoe and oxen as sources of power), such cultivars of maize are unsuitable.

TABLE 1

Broad Characteristics of the Main Types of Zambian Farms

Criteria	Subsistence	Emergent	Commercial
Crops grown and inputs used	Cassava, millet sorghum, maize, groundnuts, some fertilizer	Cotton, tobacco, maize, sunflower, pesticides, certified seed, fertilizer	Maize, sunflower, tobacco, fertilizer, certified seed, pesticides, herbicides
Main source of cash	Occasional food surplus sale, fishing, beer, charcoal	Production of cash crop surplus for sale	Production of cash crop for sale
Production of new cash crops (cotton, sunflower, soybean, tobacco)	None	Some	Some
Power source	Hand hoe and tools	Hand hoe, oxen, few tractor hire or ownership	Tractor and few oxen
Labor source	Family, communal, some casual	Family, communal, casual and few permanent labor	Permanent and casual labor
Size of farms	Usually 5 acres* (up to 13 acres)	Usually 13 acres to 50 acres	50 acres to 1500 acres
Estimated number of households	500,000(80%)	120,000(19%)	6000(1%)

Note: * One hectare is equal to 2.5 acres. This study will use acres to measure area because it is the unit most farmers are familiar with.

Sources: R. Chambers and H. Singer, "Poverty, Malnutrition and Food Insecurity in Zambia," 1981, p.26.
This is updated with information from Jansen, 1986.

to achieve economies of size, the government encouraged formation of cooperatives, state farms and the use of tractors, rather than foster small scale opportunities. The early effects of these policies indicated that only a few people benefitted and their contribution to agricultural production was insignificant. President Kaunda [1968] concluded :

> Development that is restricted to only a small part of the economic sector, to only a few regions, to only large scale production and to only highly capital intensive techniques, is, in my view, no development at all (p.25).

However, actual policy has changed only modestly. Dodge [1977] attributed this to: (1) the low priority of investment in infra-structure and services; (2) the use of capital intensive projects which affected only a small number of farmers; and (3) the use of administered prices which do not generate sufficient profits to attract investment in agriculture.

Ruttan [1973] noted that growth of agricultural output is determined by growth of the labor force, the state of technology, and the stock of human and tangible capital. Area planted depends on the amount of: (1) suitable soils, (2) credit and access to markets for supplies and sales, and (3) oxen and other sources of farm power. Walters [1982, p.10] reports that in the past two decades, increased area accounted for less than one fifth of the growth in agricultural production in developing countries and for an even smaller fraction in developed countries. In Zambia, there is still substantial area of under utilized arable land. In some areas, utilization of the land is constrained by inadequate infra-structure (e.g., roads) and sleeping sickness.[3] The latter makes some of the land uninhabitable and limits the use of animals for traction power.

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[3] Tsetse fly transmits the causal agent (Trypanosomiasis) of sleeping sickness.

Rapid increase in crop production arises from the use of more productive cultivars, chemical inputs (e.g., fertilizer), water, investment in research, land improvement and other industrial inputs. Walters [1982] argued that each by itself has limited significance but in combination, they have accounted for more than 50 percent of the increase of agricultural output in the past decades. Finally, good information is necessary to ensure correct use of inputs and the timely performance of cultural practices and to minimize the losses in harvesting, storage and distribution of agricultural products.

The current maize production policies were designed to ensure that the consumer price of maize is lower than the market determined price. To achieve this the government controls the prices of inputs and maize, and uses subsidies to offset some of the losses resulting from the policy. It is generally thought that current policies are inadequate to bring a significant impact on production. Given existing public policies and resources, there are many options to raise agricultural productivity. Among the alternative policies being considered are (1) increasing extension services; (2) improving general education; (3) using subsidies and taxes as incentives; (4) increasing the number of farmers having access to debt capital by introducing a maximum ceiling on loans from publicly owned credit institutions; (5) de-regulating controls on fertilizer and other input prices; (6) increasing product prices; (7) adjusting exchange rates; and (8) improving research capacity to develop appropriate technology.

At a time when policy changes are being considered, many policy makers believe that small scale farmers are less economic-efficient because of lower output per acre than large scale farmers. Output per acre may be misleading for it overlooks that productivity differences arise from (1) resource endowments, (2) technical inputs (fertilizer and machinery), and (3) education (Ruttan [1973]). Bessell [1968] argued that given the large areas of potentially productive uncultivated land, the subsistence sector has the greatest potential for raising production, with a relatively higher return to capital employed. However, Bessell [1976] later suggested that credit should be allocated to farmers with higher output per acre. If this basis is followed (as has been the case), most of the debt capital would go to large scale farmers. In Zambia, land is not a limiting resource, therefore output per acre is a misleading indicator of scarcity. It is important to realize that differences in abilities, constraints and goals, mean that farmers operate farms at different scales, factor input ratios, levels of technical efficiency and levels of profit. Low levels of resource endowment imply that the optimum size of small scale farms would be less than that of large scale farms. Therefore, it may be that the low crop yield per acre among small scale farmers is the economically efficient choice under their production conditions.

1.1 STATEMENT OF THE PROBLEM

There is increasing pressure to raise maize production. Since maize is produced on subsistence, emergent, and commercial farms, there is debate about the proper policy to increase maize production. The effectiveness of any policy attempting to raise maize production depends on the relative economic efficiency of different farm sizes. Differences in economic efficiency may be due to technical and/or price efficiencies. In Zambia, no systematic evaluation of the economic efficiency of different farm sizes has been conducted. Most studies [Bessell, ILO] focus on gross product volume and gross sales and neglect the net revenue data. This study attempts to analyze the relative economic efficiency of emergent and commercial maize farms in Zambia

Measuring the relative economic efficiency of the two farm groups is important in evaluating proposed policy changes (e.g., cooperative farming, credit ceiling and extension services). Therefore, this study is important to policy makers, farmers and lending institutions for it would help indicate the loss or gain from policies being proposed.

1.2 OBJECTIVES

The principal objective of this research is to determine the relative technical, price and economic efficiencies of emergent and commercial farms in Zambia. This study consists of the following objectives:

1. To estimate the relative economic efficiency of emergent and commercial farms.
2. To estimate the relative price efficiency of emergent and commercial farms.
3. To estimate the relative technical efficiency of emergent and commercial farms.
4. To determine if emergent and commercial farms operate under constant returns to scale.

1.3 MAJOR HYPOTHESES

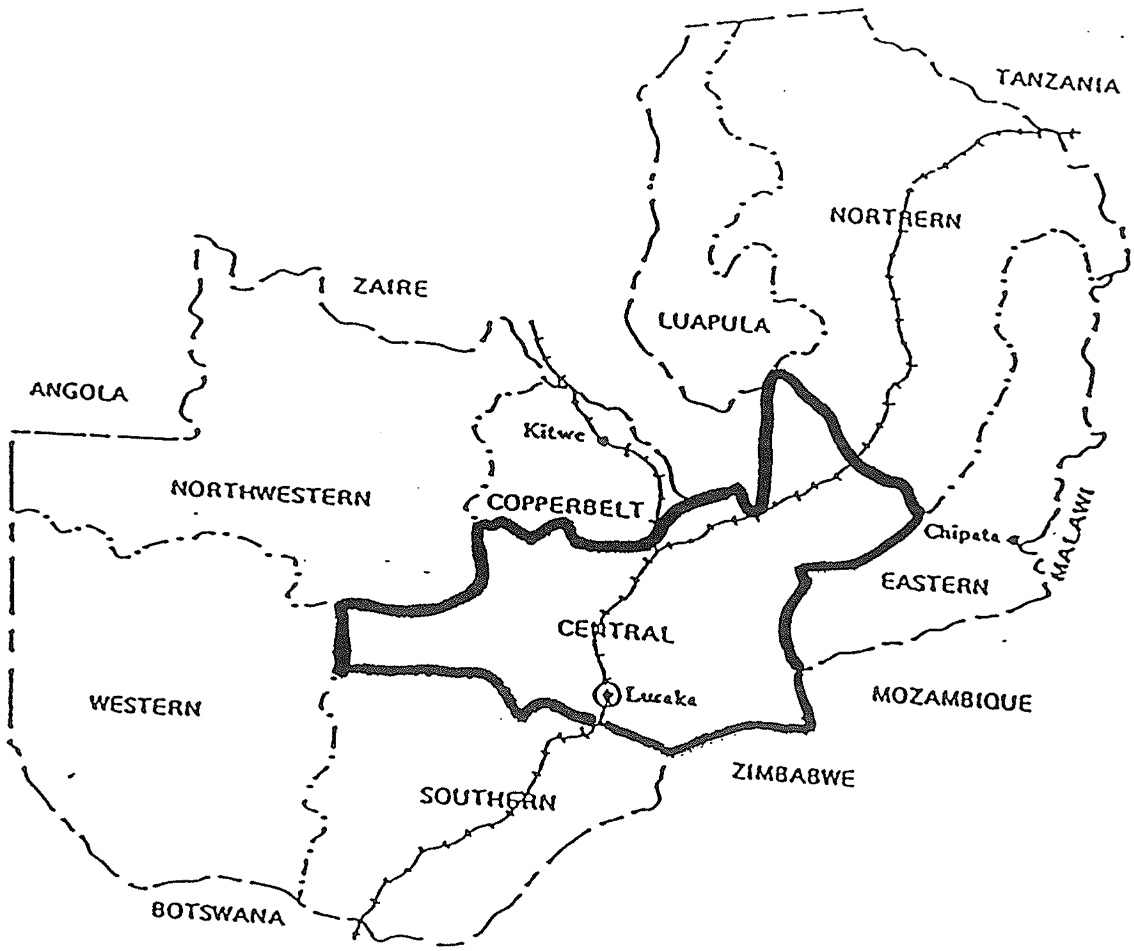
To investigate the objectives in section 1.2, four hypotheses were stated.

1. There is no significant difference in the economic efficiency of emergent and commercial farms.
2. There is no significant difference in the price efficiency of emergent and commercial farms.
3. Emergent and commercial farms have equal relative technical efficiency.
4. Emergent and commercial farms operate under constant returns to scale. Thus, efficient farms can exist in a wide range of sizes.

1.4 AREA OF STUDY

The study was carried out in three districts of Central Province, Zambia (Figure 2, p.10). Central Province was selected because it is characterized by the prevalence of emergent and large scale farms. In addition, the area has had access to good roads, railway line, and urban markets for a long time. Furthermore, the province produces most of the marketed agricultural products. Therefore, the area should reveal some of the relationships existing between emergent and commercial farms.

Figure 2: Map of Zambia Showing all Provinces and the Area of Study



Key: Scale in kilometers 0 50 150

National boundaries

Provincial boundaries

Railway line

Chapter II

THE MAIZE INDUSTRY IN ZAMBIA

Many studies have reviewed history of the maize industry in Zambia. To avoid duplication, this study identifies only the turning points in policy.

The discussion is divided into:

1. The period before 1940
2. The period between 1940 and 1963
3. The period between 1964 and 1979
4. The period between 1980 and 1986

2.1 THE PERIOD BEFORE 1940

The mining industry in Zambia started during the early 1900s.[4] In response to the needs of the mining industry, maize production emerged. The colonial government believed that African farmers could not generate the surplus maize needed to meet the growing demand from miners. Therefore, government policy before the Second World War encouraged European settler farmers. The Agricultural Advisory Board report [1935], Bock Commission report [1963], and Dodge [1977] found that colonial government policy involved allocation of fertile land to European settler farmers, excluding African farmers from agricultural loans, minimal inf-

[4] Zambia became independent in 1964. Before 1964, the country was a colony of the United Kingdom. At independence, the country's name changed from Northern Rhodesia to Zambia.

ra-structure development where African farmers were located, offering African farmers a small share of the main market, and pricing African maize below the price offered to European farmers. These gave birth to a dual agriculture in Zambia.

The Agricultural Advisory Board report [1935] found that, between 1919 and 1929, there was a small domestic market for maize. However, it was profitable to export maize to the Congo (now divided into Zaire and Congo). During the 1930/31 season, poor rainfall reduced local production to below domestic demand. Therefore, maize was imported to offset the deficit. In the early 1930s, the world depression reduced demand for copper. This forced some mines to close or operate part time. In turn, the purchasing power of miners was reduced. Because miners provided the main market, demand for maize decreased. The result was that maize prices fell. In addition, production exceeded local demand and exports were not profitable for miners in the Congo were facing the same problems. In 1936, the government intervened to control the marketing of maize, thus the selling price of maize was fixed higher than the equilibrium price. The marketing board accumulated maize surplus to maintain the fixed price.

2.2 THE PERIOD BETWEEN 1940 AND 1963

The Bock Commission report [1963] found that during the Second World War, area under maize cultivation declined while demand increased. This is because some mature men were recruited to join the British Army, thus reducing farm labor and area under maize cultivation. Demand increased because British colonies were required to support the war effort. The surplus which had been accumulated before 1940 disappeared. Domestic production of maize was usually below demand in the 1940s and early 1950s. During this period imports were used to offset deficits. Guaranteed maize prices were raised to stimulate production.

By 1954, maize production exceeded domestic demand. Once more the government started accumulating surplus production to maintain guaranteed prices and export markets offered prices below domestic prices. The government offered subsidies to consumers because producer prices were higher than consumer prices. In 1957, mounting surpluses forced the government to permit different guaranteed prices in different areas.

Therefore, between 1941 and 1953, domestic maize production was below domestic demand. By 1954, domestic production exceeded domestic demand. The problem changed from maize shortages to surplus disposal. The Bock Commission report [1963] attributed this change to:

1. Guaranteed producer prices which encouraged reinvestment of profit and higher proportions of sales.
2. Incentives which encouraged farmers to adopt measures to restore fertility of the soil.
3. Improved extension services which promoted proper husbandry practices.
4. Development of local high yielding cultivars of maize.
5. Increased use of fertilizers.

2.3 THE PERIOD BETWEEN 1964 AND 1979

Zambia became independent in 1964. The new government inherited a situation in which maize production exceeded domestic needs. After independence, production fell because some of the European settler farmers left the country. The government expected rising population (3.4% per year) and incomes to expand demand for maize. Therefore, government policy was designed to meet this challenge. Increased maize production was to be attained through small holder farms and state farms. To assist small holder farmers, the government introduced (World Bank [1984a], Dodge [1977], Jansen [1986]):

1. Special extension programs for small scale farmers to spread appropriate cultural practices.
2. Credit facilities to small scale farmers to finance input purchases.
3. Subsidies on some agricultural inputs to encourage use.
4. Marketing organizations to assist in the timely delivery of services and maize purchases.
5. High producer prices to encourage investment in the maize industry.

The achievements of these policy actions have been mixed. Table 24, (p.174) shows the supply and disposition of maize from 1964 to 1973. Between 1964 and 1967, domestic production was greater than domestic demand. Exports could only be made at a loss. The producer price was reduced to deal with the mounting surpluses and to encourage production of other crops. In the 1968/69 season, low prices and bad weather combined to reduce production below domestic needs. In 1970, producer prices were raised but production fell due to poor rainfall. In 1971, producer prices for maize were raised and fertilizer subsidies were introduced to encourage maize production. Domestic production exceeded local demand in 1971 and 1972.

Therefore, the maize industry has been characterized by government intervention. This was done to ensure self-sufficiency in maize and to avoid a build up of surplus maize, for maize exports {Tables 25, (p.175) and 26, (p.176)} from Zambia have not been profitable. The government has used marketing organizations to administer subsidies. The subsidies consist of (World Bank [1984a], Jansen [1986]):

1. Incentives to production through guaranteed prices (Table 27, p.177).
2. Subsidy to keep consumer prices lower than imported maize.
3. Subsidy on inputs to reduce farm production costs.
4. Subsidies on handling, storage and transport costs.
5. Partial payment for physical improvements of marketing organizations. This is because these organizations are not permitted by law to charge full cost for their services.

The proportions of the above subsidies vary from year to year.

After 1970, the government established uniform prices for input and crop prices throughout the country. The justification was to provide equal opportunity to farmers in remote areas with those living near markets. It was hoped that such a policy would help raise rural incomes. The costs of transport, storage and handling were funded through subsidies. The major effect of uniform pricing was increased maize production in provinces far from the main market. Jansen [1986] reports that the main beneficiaries of this policy have been Eastern Province and more recently the Northern Province. The problem is that uniform pricing encouraged production in areas where transport costs could discourage shipments to other areas. This called for increased maize transport subsidies.

2.4 THE PERIOD BETWEEN 1980 AND 1986

Between 1980 and 1986, Zambia's economic problems worsened and copper continued to be the main export. Table 28 (p.178) shows exports from Zambia. There was only marginal improvement in the price of copper and agriculture contributed very little to exports. Lack of foreign exchange to finance imports resulted in shortages of imported goods. In some years, fertilizers and other inputs needed for maize production could not be imported in time for early planting. This contributed to food production below domestic needs (Table 25, p.175). In addition, food deficits were met through imports. Therefore, food imports contributed to the debt problems the country has been facing (Table 30, p.180).

The National Commission for Development Planning (NCDP) [1987] reported that Zambia has borrowed from the IMF since 1976. The money borrowed was used to import inputs and consumer goods. In 1980, the government requested more loans from the IMF. To qualify for more loans, the government was forced to accept IMF conditions. These involved: exchange rate adjustment, price de-controls, high interest rates, liberalization of agricultural marketing and trade, reduction in government deficits, institutional reforms by encouraging competition and selling unprofitable parastatals, higher producer prices and early announcement of prices, and encouraging private sector production (World Bank [1984b]). It was argued that these conditions would assist in diversifying the economy.

NCDP [1987] reported that the government started implementing IMF conditions in 1983. In October, 1985, the government adopted the auctioning system as a means of allocating available foreign exchange. In addition, trade restrictions were relaxed. The result was that inputs needed in production became available. Because the local currency had depreciated drastically [K2.00/US $1.00 (1985) to K15.00/US $1.00 (1986)], prices of imported items became very expensive. NCDP [1987] reported that between October 1985 and April 1986, the Kwacha was devalued by 955 percent. In addition, inflation increased from 20 percent (1984) to 60 percent (1986). During the same period, interest rates increased to about 30 percent. NCDP [1987] found that investment decreased, unemployment increased, and capacity utilization in industries declined. Restrictions on government expenditures were blamed for declining welfare and social services.

Political and social considerations forced the government to continue maize and maize flour price controls. This was done through continued subsidies for fertilizer, handling and transportation. Under pressure from the IMF the government was forced to raise maize and maize meal prices. The food riots (December,1986) which followed forced the government to rescind the decision. In January, 1987, the exchange rate dropped to twenty one Kwacha per one US dollar. Faced with new IMF conditions and mounting political pressure, the government suspended the auctioning system and fixed the exchange rate at eight Kwacha per one US dollar (NCDP [1987]). The IMF was not happy with the reversals in policy and threatened not to release more loans. On the first of May, 1987, the IMF program was discontinued and replaced with a new program {New Economic Recovery Program (NERP)}. The objectives of the new program were to stabilize the exchange rate, control prices and interest rates, increase capacity utilization of existing industries, encourage reinvestment of profits, and to maintain an acceptable level of social and welfare services. However, the IMF rejected the NERP as an alternative to its program, thus Zambia decided to proceed without IMF support. It is too early to make any comments about the new program.

Jansen [1986] and the World Bank [1984a, b] reported that yield per acre was static between 1965 and 1978, and that increased production resulted from area expansion. They found that since 1979, production increased due to price incentives (Table 31, p.181). Maize price is set based on a fair return to capital. Even though small scale farmers do not own significant amounts of capital, commercial farmers are well organized and have exerted pressure on the government to base maize prices on a fair return to capital. This assumes that capital is the most limiting factor to increased production.

In an attempt to diversify the Zambian economy, the World Bank [1984a] conducted research on the comparative advantage of different agricultural products in Zambia. The study concluded that Zambia does not have a comparative advantage in maize production. This may explain why only limited quantities of maize have been exported (Table 26, p.176). However, in terms of domestic resource use, emergent farmers were reported to be the most suitable producers of maize to meet self-sufficiency (World Bank [1984a]). They argued that the position of emergent farmers is strengthened by their lower reliance upon imported inputs. Emergent farmers, guided by subsistence and market objectives, may be more productive because their survival depends on resources they have access to (World Bank [1982]). Therefore, they perform cultural practices carefully and fully utilize the limited resources. Since Zambia has foreign exchange constraints, emergent farms appear to be the group to focus on. Commercial farmers use most of the purchased inputs, yet studies show that they are less productive in terms of domestic resources. Their past dominance in agricultural production may be attributed to political influence (before and after independence) and its impact on the over valuation of the domestic currency. The result is that imported inputs tended to be cheaper than would otherwise be the case. This has encouraged the use of imported inputs.

Necessities, such as fertilizer and seed, do not reach many small scale farmers because they have neither the credit nor the cash to buy them. Requirements of security on loans excludes most emergent farmers from obtaining credit. This is because most assets of emergent farms are unacceptable as security. The result is that less than two (2%) percent of farmers (i.e., large farms) use almost 90 percent of all loans disbursed every year (CSO [1981a]).

2.5 THE CURRENT MAIZE PRODUCTION ENVIRONMENT

Maize is grown by all groups of farmers throughout the country. This section discusses the potential for maize production, the existing technology and the current production.

2.5.1 Distribution of Maize Production

Maize production dominates agricultural policy. Zambia is capable of producing maize to meet domestic demand. In some years, surplus maize is produced. Table 2 shows marketed production of maize by province, since 1982. During this period, the area under maize cultivation was distributed as follows: Eastern Province (40 percent), Central Province (22 percent) and Southern Province (19 percent.) That is, the three provinces accounted for about 81 percent of the total maize area. Since 1982, total area under maize cultivation has expanded by 28 percent (for Zambia). The highest area expansion was on the Copperbelt (109%), with the least from Eastern province (5.0%). In other maize producing provinces, maize area increased as follows: Central (18%), and Southern (58%). In the rest of the provinces, maize area expansion was between 5 and 109 percent. These figures indicate that future maize production may come from provinces other than Eastern and Central Provinces. This may be due to the fact that other provinces still have large uncultivated arable areas. In addition, the new cultivars (p.27) cover many micro-climatic zones, thus they may have encouraged production in other provinces. Jansen [1986] reported that relatively high maize prices (between 1980 and 1985) contributed to area expansion.

TABLE 2

Maize Production and Marketings by Province, 1982-85

		Area (acres)	Yield (bags/acre)*	Production (bags)	Retained (bags)	Marketed (bags)	Marketed Value (K'000)**
Zambia							
	1985	1454800	8	12470800	5401163	7069637	200212
	1984	1266300	8	9686000	3418363	6347637	153557
	1983	1366800	8	10392000	4490176	5901824	108003
	1982	1136300	7	8336000	2630422	5705578	91289
Central							
	1985	296800	11	3172000	939368	2232632	63228
	1984	252500	11	2759000	641222	2117778	51886
	1983	367500	9	3301000	1064286	2236714	40932
	1982	252500	8	2168000	482662	1685338	26965
Copperbelt							
	1985	38800	8	321500	79779	241721	6846
	1984	26000	7	183000	49576	133424	3269
	1983	19300	8	159000	68780	90220	1651
	1982	18500	6	113000	47300	65700	1051
Eastern							
	1985	515000	7	3668600	1887973	1780627	50427
	1984	535000	6	3319000	1469761	1849239	45306
	1983	552500	6	3096000	1496432	1599568	29272
	1982	490000	5	2465000	1191591	1273409	20375
Luapula							
	1985	13500	8	109300	50580	58720	1663
	1984	11300	8	95000	23909	71091	1742
	1983	8500	8	73000	32845	40155	735
	1982	7300	8	60000	9787	50213	803
Lusaka							
	1985	80800	8	720000	452616	267384	7572
	1984	62500	7	460000	346845	193155	2772
	1983	62500	8	495000	277572	217428	3979
	1982	56800	7	390000	138000	252000	4032

...continues next page

TABLE 2 (continues)

	Area (acres)	Yield (bags/acre)	Production (bags)	Retained (bags)	Marketed (bags)	Marketed Value (K'000)
Northern						
1985	117000	9	1073900	335449	738451	20913
1984	106000	10	1000000	249448	750552	18389
1983	89300	14	1217000	563965	653035	11951
1982	61300	15	664000	15410	648590	10377
N. Western						
1985	13300	8	111900	37256	74644	2114
1984	10500	9	93000	25859	67141	1645
1983	12000	8	95000	43737	51263	938
1982	10500	6	67000	17317	49683	795
Southern						
1985	335000	9	3086200	1502320	1583880	44855
1984	225000	7	1607000	531187	1075813	26357
1983	200000	9	1808000	845177	962823	17620
1982	212500	15	2307000	664557	1642443	26279
Western						
1985	44800	5	207400	115822	91578	2593
1984	37500	4	170000	80556	89444	2191
1983	55300	3	148000	97382	50618	926
1982	27000	4	102000	63798	38202	611

Note: *Maize is measured in 90 kilogram (Kg) bags.
**Kwacha (K) is the Zambian currency. In 1987, one US dollar was equal to eight Kwacha.

Source: Ministry of Agriculture and Water Development, Agriculture Statistics Bulletin, Lusaka, Zambia, December, 1985, p.11.

Generally, total annual production of maize in the Eastern Province exceeds any other province, with Central Province a close second and Southern Province a distant third (except in 1985). On average, Central Province markets more than 73 percent of its total production. This is probably due to the good environmental conditions (as shown by the higher average yield per acre and the ratings of soil potential for maize production), the large number of commercial farmers, access to maize deficit areas (Central and Copperbelt Provinces) and transport to deliver inputs and maize. Southern and Eastern Provinces market 61 and 52 percent of their total production, respectively. The World Bank [1984a] reports that most of the commercial farms are in Central and Southern Provinces. Southern Province has more commercial farmers than Eastern Province.[5] This may explain why the percentage of marketed production is higher in Southern Province than in Eastern Province. It may be argued that where small scale farmers dominate production, a significant proportion of production is retained for home consumption.

2.5.2 Maize Growing Areas

Research has classified the different provinces into zones. This is based on the maize production potential (Figure 3). Zone III consists of high rainfall areas (about 1000 mm/year): Northern, North Western, Copperbelt, Luapula and partially Central Provinces. Zone I consists of intermediate rainfall areas (about 800 mm/year): most of Eastern, Central, Lusaka, and Western Provinces. The northern part of zone I is

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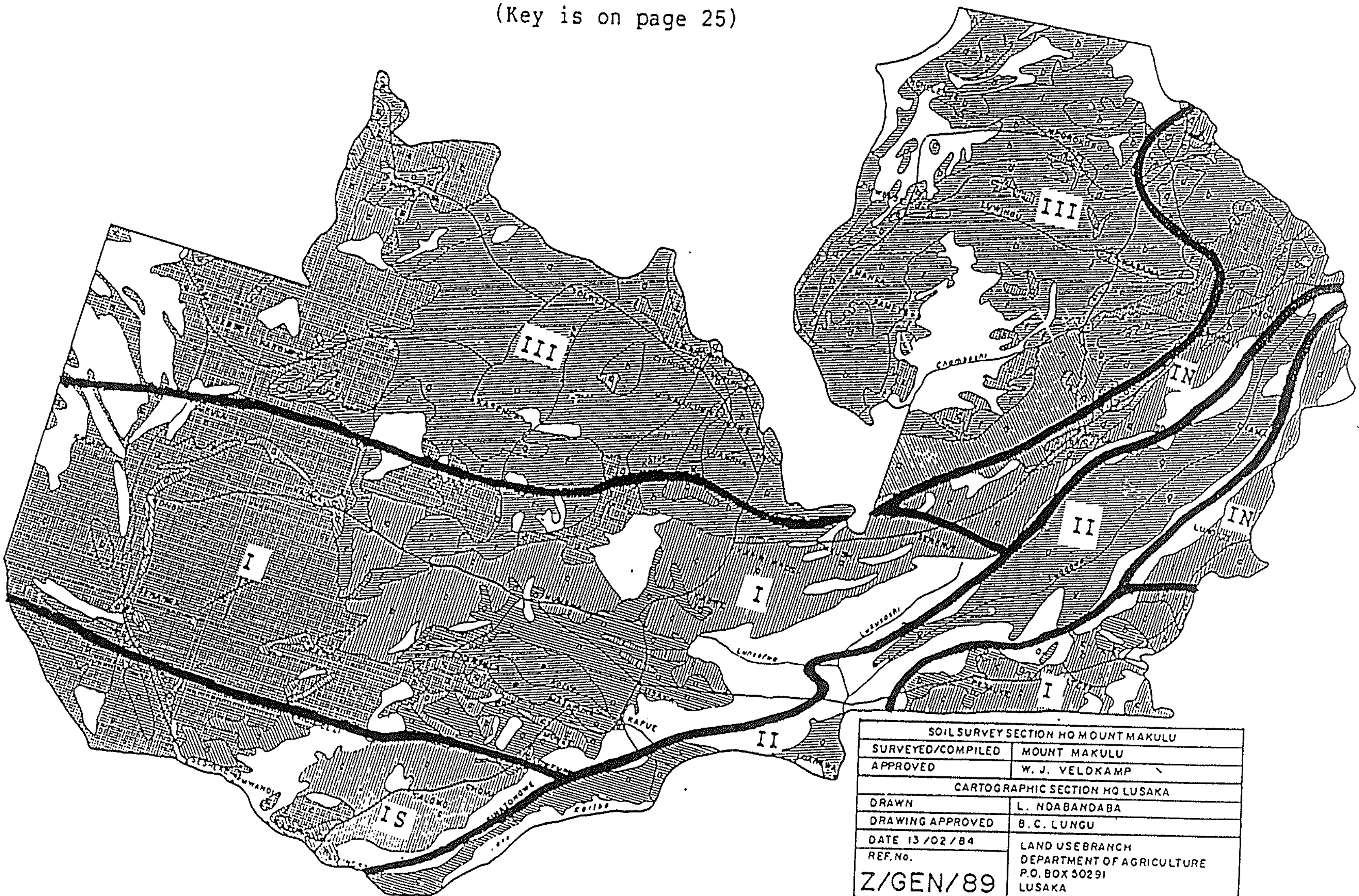
[5] This is based on the personal knowledge of the author. Most studies (Jansen [1986], World Bank [1984a], Chambers and Singer [1981]) have estimated the number of commercial and emergent farms for Zambia and not per province.

Figure 3: Potential Maize Growing Areas of Zambia
(Key is on page 25)



Key to the Potential Maize Growing Areas of Zambia:

GENETIC POTENTIAL	ZONE
High	I
Moderate (insolation limiting)	IN
Moderate (drought)	IS
Marginal (insolation limiting)	III
Low	II

SOIL POTENTIAL			
MAP UNIT	SOIL SUITABILITY RATING	SUBUNIT	MAJOR LIMITATIONS
	Highly to moderately suitable, F 1–2.	a	None
		b	Erosion: slight to moderate
		c	Erosion: slight Alkalinity: moderate Soil depth: limited extent of arable land in entire map unit (80-90%)
	Highly to marginally suitable, F 1–3	a	Acidity: slight to moderate
		b	Erosion and soil degradation: slight to severe Texture: very fine in places occasionally coarse
		c	Erosion and soil degradation: slight to severe Acidity: slight Texture: coarse
		d	Erosion and soil degradation: slight to severe Acidity: slight Texture: coarse Soil depth: limited extent of arable land in entire map unit (50 %)
	Moderately to marginally suitable, F 2–3	a	Erosion and soil degradation: slight to severe Acidity: moderate Texture: coarse
		b	Soil depth: shallow soils dominant, limited extent of arable land in entire map unit (50%)
		c	Acidity: moderate to severe
		d	Acidity: moderate Texture: coarse to very coarse
	Moderately suitable to unsuitable, F 2–4	a	Erosion and soil degradation: slight to moderate Acidity: moderate to severe
		b	Erosion and soil degradation: moderate to very severe Acidity: moderate to severe Texture: coarse
		c	Acidity: moderate to severe
		d	Erosion and soil degradation: moderate to very severe Acidity: moderate to severe Soil depth: limited extent of arable land in entire map unit (40%)
		e	Wetness: moderate to very severe Alkalinity: moderate Texture: very fine
		f	Wetness: moderate to very severe Acidity: moderate to severe
		g	Wetness: moderate to very severe Texture: very fine Alkalinity: moderate to severe Erosion: slight to very severe
	Marginally suitable to unsuitable, F 3–4	a	Wetness: severe to very severe
		b	Wetness: moderate to severe Acidity: moderate to severe Texture: very coarse
		c	Acidity: severe Texture: very coarse Erosion: slight
	Unsuitable, F 4	—	Variable (erosion, wetness, soil depth, acidity, alkalinity, texture) limitations.

similar to zone III and is called zone IN. The southern part of zone I is similar to zone II and thus called zone IS. Zone II consists of the low rainfall areas: Zambezi, Luangwa and parts of Western Province. Figure 3 indicates that Zambia has large arable areas for maize production. The different micro-climatic conditions suggest that a uniform policy is not appropriate to all areas. This means that research has to consider differences in the potential of each zone before making any recommendations.

2.5.3 Maize Breeding

Technological progress offers a way of raising maize production. The national research station (Mount Makulu) and provincial testing centers were assigned the task of developing new cultivars and adapting existing cultivars to the climatic and management conditions in Zambia. Hybrid seed embodies technological change.

The introduction of SR52 in the late 1950s, helped increase yield per acre. Since then yield per acre remained static (Jansen [1986], and World Bank [1984a]). In the late 1970s, some farmers complained about declining yields from SR52. Research attributed the decline to contamination of the cultivar. In addition, little or no effort was made to develop cultivars less dependent on purchased inputs. To address these problems, research was initiated to develop new cultivars suitable for different climatic zones and management levels. The cultivars noted in Table 3 were released in 1985. The number of cultivars released, and their micro-climatic and management distribution indicate substantial progress in hybrid maize technology.

TABLE 3

Description of Maize Varieties

Name of Cultivar	Days to Maturity	Suitable Zone*	Management Needed	Yield Potential 90 Kg bags per Acre**	Availability 1985 to 1986
MMV400	100	II	Low and Medium	13	Yes
MM501	115	IS, IN	Medium and High	22	No
MM502	130	IS, IN	Medium and High	27	Yes
MM504	125	IS, IN	Medium and High	22	Yes
MM601	130	IS, IN	Medium and High	27	Yes
MM504	125	IS, IN	Medium and High	22	Yes
MM601	130	I	High	31	Yes
MM603	135	I	Medium and High	31	Yes
MM604	135	I	Medium and High	31	Yes
POP10	125	I	Low and Medium	13	No
MMV600	135	III, I	Low and Medium	22	Yes
ZUCA	145	III	Low and Medium	18	No
MM752	150	III, I	High	36	Yes
SR52	150	III, I	High and Medium	31	Yes

Note: The descriptions are based on data available in July, 1985.

* Zones are defined on page 24

** One hectare (ha) equals 2.5 acres.

Source: Compiled from Mount Makulu research data (1986) with the assistance of Mr. Watson Mwale, a maize breeder.

Zambia Seed Company (Zamseed) controls seed maize production in Zambia.[6] A rigorous campaign has raised domestic seed production. Before this drive, most of the seed maize was imported. Use of certified seed has not yet spread to all maize producers (due to cash and local availability constraints). As many farmers adopt the new hybrids, maize production is expected to increase and this may later lead to a decrease in food prices. If production costs are unchanged, then profits of farmers may decrease and this could discourage maize production. Therefore, efforts are needed to maintain producer incentives so that farmers can be encouraged to adopt existing technology.

Zamseed has found profitable export markets in the surrounding countries. The profitability of seed maize exports was enhanced by 1986 exchange rates. Measures to over-value the Kwacha may reduce this export potential. This indicates the existence of markets for surplus seed maize and offers a way to expand trade with the neighboring countries. Because production of seed maize requires some knowledge of maize breeding (which many emergent farmers do not have), appropriate incentives could attract commercial farmers to this sector. Before encouraging farmers to increase seed maize production, it is necessary to evaluate the potential for export.

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[6] Zamseed is about 60 percent privately owned. This is based on personal discussions with Zamseed officials in 1986.

2.5.4 Planting

In Zambia, the rain season begins in November. Maize is produced under rain-fed conditions. Even though preparations for maize production begin early, maize is planted in November and early December. To obtain high yields, early tillage and planting is recommended. This has not been possible for subsistence and emergent farmers because the soil becomes hard during the dry season, thus making it difficult to plough fields before the beginning of the rain season. Because subsistence and emergent farmers depend on the hand hoe or oxen as sources of farm power, tillage does not start until the beginning of the next rain season, thus delays planting. Crop scientists report that yield per acre decreases with delays in planting. This suggests that an increase in farm power could permit ploughing during the dry season and enable early planting and higher yields. In Zambia, this would imply importing machinery. Foreign exchange constraints and non-availability of maintenance facilities imply that efforts have to be made to expand oxen use and to develop maize cultivars with short maturing periods, so that delays in planting time would not significantly reduce yield.

2.5.5 Fertilizer

One fertilizer plant (Nitrogen Chemicals of Zambia) manufactures some (40%) of the fertilizers needed. The National Agricultural Marketing Board (Namboard) has the mandate to import (60%) and distribute fertilizer.[7] Since Namboard is a parastatal, the government determines the

[7] For 1984/85 and 1985/86 seasons, Namboard imported about 60 percent of fertilizer. Nitrogen Chemicals of Zambia supplied about 40 percent of fertilizer. These figures were calculated from information provided by Namboard Accounts Department in 1986.

price of fertilizer. In the past, a uniform price has been applied throughout the country. Dodge [1977], Jansen [1986] found that setting prices below world market levels has encouraged smuggling across the border, where fertilizer prices tend to be higher than in Zambia. In some years, lack of foreign exchange and transport problems have forced Namboard to import fertilizer late. Applying inputs late results in lower yields.

Through fertilizer trials, research has recommended that 80 to 120 kilograms (Kg) of compound D (10% Nitrogen, 20% P_2O, 10% K_2O and 10% sulphur) per acre, be applied at planting (usually called basal dressing). Top dressing, consisting of 80 to 100 Kg of Ammonia Nitrate or Urea (34% or 46% Nitrogen, respectively) per acre, is applied when seedlings reach 50 to 60 centimeters. These recommendations are based on soil analysis and indicate that growth of the maize plant depends on the nutrients provided by fertilizer. Usually, a single recommendation covers the entire province, even though soils differ from farm to farm (in fact soils may differ within the same farm). This suggests the need to conduct research in different micro-climatic zones to determine the appropriate quantities for each zone.

2.5.6 Plant Protection and Harvesting

Weeds reduce yields by competing for nutrients, moisture and sunlight. Weeds are controlled through cultivation or application of herbicides. Insect damage is reduced through use of insecticides. To attain high yields, weed control has to be done at appropriate stages of plant growth. Among subsistence farmers, hand hoes are used to control weeds. Emergent farmers use ox-drawn cultivators to control weeds. Commercial farmers use either herbicides and/or tractor drawn cultivators.

In Zambia, maize is harvested between June and August. Among small scale farmers harvesting is done by hand while most commercial farmers use combine harvesters. Where combine harvesters are not used, shelling is done by hand (subsistence and emergent farmers) or shellers (for commercial farmers). Maize is then packed in 90 Kg bags for delivery to marketing depots, where a fixed price is paid per bag.

2.5.7 Agricultural Credit

Attractive maize prices and existence of more productive cultivars of maize are necessary but not sufficient conditions for increasing maize production. They must be accompanied by policies to encourage adoption of hybrid seed. Most of the farmers do not have extra cash to meet all costs associated with hybrid maize production. Therefore, availability of credit could play a significant role by raising the input budget, thus enabling farmers to obtain additional inputs.

At independence (1964), the demand for agricultural loans was greater than the pool of loanable funds for agriculture.[8] In addition, private banks were not willing to extend loans to farmers with no acceptable collateral. In order to increase the pool of loanable funds and assist emergent farmers with no collateral, the government created the Agricul-

[8] The material presented in this section is based on personal discussions with AFC officials in 1986 and material from the World Bank [1984a].

tural Finance Company (AFC).[9] In addition, the government appealed to private banks to increase lending to agriculture. At the same time the government introduced controls on interest rates (less than 20%) paid on savings and loans with a view to reducing the cost of capital. The National Commission for Development Planning [1987] reported that inflation increased from 20 percent in 1976 to 60 percent in 1986. At such inflation rates, real interest rates may be very low or negative. The problem is that low interest rates discourage savings and therefore reduce the pool of loanable funds. AFC was required by law to lend to all groups of farmers. To partially offset some of the extra costs associated with processing small loans, the government provided subsidies to AFC.

Credit is needed to help finance purchased inputs. As more purchased inputs are used, there is increased reliance on credit. The Central Statistical Office [1981a] conducted a study to determine the annual amounts of loans lent to agriculture (Table 4). Between 1970 and 1984, nominal amounts of loans increased by 1180 percent. Except for the 1979/80 season, annual nominal amounts lent to agriculture increased. Since inflationary pressures were high the Wholesale price index for agriculture (Table 32, p.182) was used to derive the real annual amounts of loans released.[10] In 1975, world copper prices started declining,

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[9] AFC was dissolved and its assets and liabilities were transferred to Lima Bank in 1987. AFC was established in 1970 as a successor to the Credit Organization of Zambia (COZ). COZ was preceded by the Land and Agricultural Bank in 1964.

[10] The Wholesale price index measures changes in prices of commodities at their first important commercial transaction and refers to prices of large lots in primary markets. The index for agriculture is used to estimate the purchasing power of annual loan disbursements.

TABLE 4

All Sources of Farm Loans Released 1970/71 to 1983/84

Year	Nominal Amount Released (K)	Nominal % Increase Over Previous Year	Real Amounts Released** (K)	Real % Increase Over Previous Year
1970/71	12.1	–	14.9	–
1971/72*	13.3	9.9	16.4	10.1
1973/74	17.3	30.1	21.3	29.9
1974/75	28.0	61.8	28.0	31.5
1975/76	41.0	46.4	35.1	25.4
1976/77	51.4	25.4	41.0	16.8
1977/78	63.2	23.0	43.5	6.1
1978/79	71.7	13.4	41.1	-5.5
1979/80	65.7	-8.4	34.1	-17.0
1980/81	87.4	33.0	38.9	14.1
1981/82	125.6	43.7	43.1	10.8
1982/83	150.1	19.5	44.6	3.5
1983/84	154.9	3.2	37.6	-15.7

Note: * Data not available for 1972/73 season

** Real amounts are derived using 1974/75 as a base year

Source : Central Statistical Office, Lusaka, Zambia, 1981a, p.2
Data has been updated with information from MAWD, June 1986, p.40

thus reducing revenues from copper exports. This reduced foreign exchange earnings and marked the beginning of economic problems in Zambia. This also reduced the ability to import goods and contributed to inflation. The impacts of low world copper prices were not felt until 1976. Therefore, the 1974/75 wholesale price index is appropriate for deflating loans released in different years.

Between 1970/71 and 1974/75, real annual amounts lent to agriculture increased at an increasing rate. When copper prices started declining (1975), the real amounts lent to agriculture increased at a decreasing rate until 1977/78. This may have been a result of decreasing government revenues from copper and its effect on the amount of subsidies provided to agricultural credit. In 1978/79 and 1979/80, the real annual amounts lent to agriculture decreased. This reflected worsening economic problems and decreasing government grants to AFC. Between 1980/81 and 1982/83, real amounts again started increasing at a decreasing rate. The increase may have come from loans (IMF) and increased focus on agriculture. In 1983/84, the real amount disbursed decreased. In general, real annual loan disbursements more than doubled. This means that increases in nominal terms were used to offset inflation.

Most of the loans disbursed are for crop inputs (Table 33 p.183). Because maize is the dominant crop, it received the largest proportion. The remainder of the annual disbursements were used to finance other crops, livestock and machinery.

Table 5 indicates that allocation of loans is biased towards provinces with the highest concentration of commercial farmers, i.e., Central,

TABLE 5

Percentage Distribution of Loans Released to Provinces 1970-1984

Province	1970/ 1971	1971/ 1972*	1973/ 1974	1974/ 1975	1975/ 1976	1976/ 1977	1977/ 1978	1978/ 1979	1979/ 1980*	1983/ 1984
Central, Lusaka and Southern	92.8	92.3	90.4	91.8	92.9	88.8	88.1	80.9	83.8	78.3
Other Provinces	7.2	7.7	9.6	8.2	7.1	11.2	11.9	19.1	16.2	21.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Note: * Data not available for 1972/73, 1980/81 to 1982/83.

Source: Central Statistical Office (CSO), Lusaka, Zambia, 1981a, p.3. Data for the 1983/84 season is from MAWD, [1986], p.9.

Lusaka, and Southern Provinces. On average, other provinces combined receive less than 20 percent of the annual disbursement. This differential access to credit may partially account for differences in marketed quantities of maize from different provinces. This is because credit increases the total input budget. Other factors which could explain differences in the quantities of inputs used are lack of information and local availability of inputs.

Between 1979/80 and 1983/84, about 40.7 percent of the total amount of farm loan applications was granted.[11] It is true that some of the applicants did not meet the criteria for loan approval or requested amounts greater than their needs. Even so, 60 percent rejection sug-

[11] Calculated from data in MAWD [1986, p.40].

gests that there is an excess demand for loans. CSO [1981a] reports that most of the applicants turned down were small scale farmers (subsistence and emergent). In discussions with private banks, they identified some of the reasons for rejecting small farm loans: lack of security, high loan processing costs, and poor managerial abilities of emergent farmers.

Most commercial farmers no longer deal with AFC because their assets have enabled them to qualify for private bank loans. Even though interest rates on private bank loans tend to be higher than on AFC loans, the flexibility of credit lines has been a major attraction. This has often worked in favor of commercial farmers. For example, private banks allow their good customers to open next season's loan (Pre-Seasonal Loan) before repaying the amount due.[12] This facility has enabled commercial farmers to buy some inputs at last year's prices. The government policy of controlling fertilizer prices and the fact that prices always rise substantially every year, encouraged this practice. Small scale farmers who depend on AFC cannot pre-pay because their credit lines are opened after the accounts due are paid. Even if there are storage and interest costs associated with advance purchases, commercial farmers realize savings in expenditures. The practice may be contributing to the shortage of inputs in a given year, i. e., farmers buy next year's requirements from this year's supply, thus by the time emergent farm loans are released, a shortage of inputs has emerged.

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[12] This was mentioned in discussions with private banks and commercial farmers in 1986. Banks refused to release any of their documents for reference.

2.6 OVERALL PERFORMANCE OF THE MAIZE INDUSTRY

Maize is grown by all groups of farmers and constitutes the staple food of Zambia. From the time the market for maize was established, there have been attempts to increase production at a rate consistent with the growth of domestic demand. Increased maize production is needed to feed the rising population (about 3.1 percent per year, CSO [1985]) and to raise the living standards of many farmers involved in production.

Performance of the maize industry may be examined through the expansion of area under maize cultivation and the growth of total output of maize. Maize area has expanded from 0.23 million acres in 1964/65 to 1.5 million acres in 1985/86. The area is expected to increase because of the new cultivars that are suitable to many micro-climatic zones and increased government efforts and incentives to raise maize production. During the same period, marketed maize has expanded from 2.14 million bags (1964/65) to about 10.2 million bags (1985/86).[13] Between 1964 and 1980, most of the increase in output has been attributed to area expansion. In the 1980s, output increase is reported to have come from the new hybrids, price incentives and area expansion (World Bank [1984a, b], Jansen [1986]).

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[13] This implies that marketed maize per acre decreased from 9 bags (1964/65) to 7 bags (1985/86), i.e., 22% decrease. The decrease may have been due to the contamination of the cultivar (SR52) and this encouraged research to develop new cultivars. Limited quantities of new cultivars were introduced in 1985, thus they did not significantly affect marketed yield per acre. It is also possible that data from 1985/86 is more reliable than 1964/65. This is because Zambia became independent in 1964 and had not developed capability to collect and process data. In 1964/65 maize production was dominated by commercial farms. In 1985/86 maize production was dominated by emergent farms. Therefore, the decrease reflects these shifts and the resource endowments of the two farm groups.

Hybrid maize production appears to have been successful in districts with favorable soils, concentration of administration, extension and input supply services. Zone I (Figure 3, p.24) has progressed beyond other zones. This is expected in that the zone has the best soil potential and support services. This means that provision of the support services in other areas could assist in the expansion of maize production.

In good years, Zambia produces enough maize to meet domestic demand. Maize output fluctuates due to drought, too much rain, low prices of maize, and input supply constraints (EEC [1980]). In surplus years, maize is exported (Table 26, p.176). During deficit years, maize is imported (Table 25, p.175). It appears that the National Agricultural Marketing Board rushed into maize export. This is because there have been periods when exports in one year were followed by imports. This suggests the need to build storage facilities for surplus maize. Since maize surpluses are erratic, exports of maize should be discouraged until a clear pattern of production is established. Therefore, policy should first focus on meeting domestic needs and later address export possibilities. Evidence shows that current production costs do not favor exports (World Bank [1984a]). The new maize cultivars have opened opportunities for increasing maize production. Efforts have to be made to enable emergent farmers to have access to this technology. The new cultivars of maize combined with fertilizer and appropriate policy offer a feasible way of raising production. Finally, limited exports of seed maize indicate the existence of markets for surplus seed. This area needs evaluation to establish the potential for export.

Previous sections reviewed the history of the maize industry. Some policies to increase maize production were identified. The next two sections summarize environmental and production constraints to increased maize production.

2.7 ENVIRONMENTAL CONSTRAINTS

The EEC [1980] argued that maize production potential of an area depends on the availability of arable land, favorable climate, water, population density and transport. In some years, poor rainfall tends to reduce maize production. Even though arable land is not limiting, lack of roads in many areas and tsetse fly limit availability of land. Different qualities of land require area specific production recommendations.

Good roads and railway services are necessary for delivering inputs and collection of products. Before the onset of foreign exchange constraints, some resources were devoted to infra-structure development (e.g., construction and maintenance of roads). Foreign exchange constraints have forced the government to postpone infra-structure development and repair (World Bank [1984a, b]. This is despite the fact that there is increased focus on agriculture. If this trend continues inputs will not be delivered and produce collected at the right time. Because these are dis-incentives to production, total production of maize may decrease. On an international level, the land locked nature of the country affects the timely availability of imported inputs, thus delaying planting time and lowering yield per acre. This implies that improvements in road and railway services (domestic and foreign) would contribute to increased maize production.

2.8 SUMMARY OF PRODUCTION CONSTRAINTS

The cultural practices used depend on the farm group. Among subsistence and emergent farms, land preparation and planting is often delayed due to shortage of farm machinery. The EEC [1980], Dodge [1977], and Jansen [1986] found that delays in the approval of loans and payment for maize contribute to the shortage of farm power and the timely purchase of inputs. In some areas, oxen use is constrained by tsetse fly. Furthermore, subsistence and emergent farms are often accused of using low plant density, small quantities of fertilizer and inadequate weed control (EEC [1980]). Until recently, subsistence and emergent farmers were not given consideration in the development of maize cultivars to suit their resource levels (EEC [1980]). In addition, the EEC reported that poor organization and lack of transport affected the performance of extension workers. The EEC also found that research recommendations were of limited applicability to subsistence and emergent farms.

The input levels of small scale farmers are such that only low levels of production per acre can be obtained. In order to increase maize production, additional inputs are necessary but many farmers do not have sufficient cash or access to credit.

2.8.1 Credit

Credit can play an important role in making some of the purchased inputs available. The government policy of low interest rates may have discouraged savings and limited the supply of loanable funds. To ration available funds, AFC and banks employ non-interest criteria (political considerations and arbitrary limit on the size of emergent farm loans). The result is that a large part of the subsidized credit goes to the provinces where large farms are located. CSO [1981] reported that most of the loans go to large farms. This defeats one of the objectives of government control of the capital market, namely assisting emergent farmers to obtain credit. Because AFC interest rates were set lower than private bank controlled interest rates, it contributed to AFC deficits and continued reliance on government grants to offset them.

Low interest rates may also lead to inefficient use of resources. EEC [1980] found that commercial farms use higher than recommended levels of fertilizer. On the other hand, the EEC reported that some farmers sold subsidized fertilizer in surrounding countries, where prices are higher. If the money raised from reselling fertilizer across the border is spent on non-agricultural projects, the pool of loanable funds available to agriculture would be reduced. The low interest rates may also reduce incentives for commercial farmers to use their equity to finance production, i.e., it is cheaper to use credit.

Low interest rates, over-valued currency and duty free imports of agricultural machinery and other inputs may stimulate capital intensive maize production. Most commercial farms are more capital intensive than emergent farms (Jansen [1986]). Since most of the farm capital is imported, it contributes to the balance of payments problems the country is facing. In addition, capital intensive production may contribute to rural unemployment and underemployment.

Therefore, the policy of low interest rates on agricultural loans may be preventing the expansion of production. This is because it limits the supply of loanable funds, number of farmers having access to credit, and quantity of inputs used.

2.8.2 Price of Maize

The EEC [1980], National Commission for Development Planning [1987], Dodge [1977], Jansen [1986] reported that the government policy of subsidizing maize meal is politically difficult to reverse because of the negative impact on the purchasing power of the low and middle income people. Brown [1978] argued that higher product prices stimulate production by encouraging farmers to: (1) operate near the production possibility frontier, (2) use more variable inputs to reach higher output levels, and (3) invest and adopt more productive technologies. If prices are prevented from reflecting the opportunity cost, these adjustments cannot take place. Many reports (Bessell [1976], Dodge [1977], ILO [1981], and World Bank [1984a, b]) found that Zambian producer prices of maize are inadequate to encourage production. In addition, late announcement of input and output prices create uncertainty, and thus discourage production.

Price controls are often defended as necessary to maintain the real incomes of urban consumers. Brown [1978] dismissed this argument because:

1. It is based on short term income effects and ignores the long run production increase and the likely price decrease.

2. It assumes that incomes are unchanged and that workers would not bargain for higher wages to maintain real income.
3. It ignores short run adjustment to reduce income loss, e.g., shift to lower priced substitute foods.

Because of these forces, Brown concluded that if agricultural producer prices increased, profits of non-farm industries would decrease and not income of labor. He suggested that the poorest urban consumers could be protected through direct subsidies (e.g., discount coupons issued to the poor) rather than producer price controls.

Low maize prices produce low profit, thus prevent attraction of resources needed to increase production. In addition, they may discourage production of alternative sources of starch (e.g., cassava). Because maize is relatively cheaper, consumers may have been encouraged to use maize meal, thus depressing demand for substitutes to maize. If producer prices of substitutes become too low, farmers may be discouraged from producing substitutes. If maize prices are raised, maize flour would be relatively more expensive, thus consumers may increase demand for substitute foods. If prices of substitute crops rise, they would encourage production of substitute crops and also help to reduce the problems associated with maize failure.

Another problem is that price controls could lead to undesirable income distribution. Most of the people producing maize are relatively poorer than urban consumers. If maize is under priced, then producers subsidize consumers. Input subsidies were introduced to partially offset some of the effects of under pricing maize. The benefits of input subsidies are proportional to the quantity of the input used. Because emergent farms use small quantities of subsidized inputs and produce about 60 percent of marketed maize, they bear most of the costs of subsidizing consumers.

Low maize prices may also encourage diversion of resources away from maize. Some commercial farmers reported that they switched to beef production because it is relatively more profitable (World Bank [1984a]), less affected by drought and requires few purchased inputs. This switch increases the supply of beef, which is used by the upper and middle income consumers, and decreases maize production. Because maize deficits have to be imported, often at higher prices, they contribute to the balance of payments problem.

2.6.3 Input Subsidies

Input subsidies were introduced to partially reduce the loss in potential farm income, which results from lower maize price. In addition, the government wanted to use subsidies to encourage adoption of more productive techniques to increase maize production. Brown [1978] and Abel [1978] argued that temporary subsidies have some merit where farmers have never used the input. Many farmers know the importance of fertilizer and other inputs. Therefore, subsidizing inputs to encourage adoption may no longer be a valid argument.

Several studies (Dodge [1977], World Bank [1984a, b] and ILO [1981] report that consumers have benefited from the subsidies more than producers. In addition, subsidies are not effective in raising the incomes of emergent farmers because they use little or no subsidized inputs. Because commercial farmers use most of the subsidized inputs, they are partially compensated and their losses from price controls are reduced.

Dodge[1977] and Jansen[1986] reported that transport subsidies have encouraged production of marketed maize in areas with no comparative advantage and diverted resources from products with comparative advantage. Dodge found that Eastern Province has comparative advantage in groundnuts. When uniform pricing was introduced maize production increased while groundnut production decreased. A possible explanation is that resources were diverted from groundnuts to maize production because of maize transport subsidies. The result is that exports of groundnuts decreased and maize transport subsidies increased. Because surplus groundnuts was exported, a decrease in groundnut production contributed to the balance of payments problems, thus the country lost. However, individual farmers who switched to maize production benefitted from the subsidy.

Therefore, subsidies may be distorting the comparative advantage of different regions. Since the country is trying to diversify exports, it is necessary to address this problem.

2.8.4 Maize Technology

A higher price of maize is not the only factor needed to raise the production of maize. Brown [1978] argued that incentives are a function of net income and not just prices, and that new technology may change the incentive effect of a given set of prices, e.g., the introduction of hybrid maize raised yield per acre (Jonsson [1977]). Evidence (Table 3, p.27) shows that there has been considerable progress in the development of maize hybrids for different micro-climatic zones, and management and resource levels. Recognizing the potential, Bessell [1973] noted that considerable increase in maize production could be obtained by encouraging small scale farms to use more productive cultivars of maize and proper cultural practices. Therefore, it is necessary to ensure that farmers obtain inputs.

2.9 SUGGESTED SOLUTIONS TO CONSTRAINTS

Both environmental and production constraints limit maize production. In this study, the focus is on production constraints. They are related to the other constraints, which have been adequately covered in many studies cited. To deal with the production constraints, a number of solutions have been proposed (EEC [1980], Jansen [1986], and World Bank [1984a, b]):

1. Provision of additional sources of farm power. This includes making tractor hire services and oxen available. It is hoped that this would encourage early tillage and planting. Jonsson [1977] reported that early planting enables the maize plant to get established and thus contributes to higher yields per acre.
2. Improve marketing and credit services to enable timely purchase and application of inputs. This implies that timely applications of appropriate quantities of inputs could produce higher yields. This means that commercial farmers obtain higher yields than emergent farmers.

3. Improve incentives to maize production. This involves offering higher producer prices, and announcing input and maize prices early. This implies that profit level and its uncertainty are problems. This may arise from anticipating inadequate maize prices and higher input costs.
4. Develop appropriate technological systems for small and emergent farmers. This suggests that different farm groups do not use the same technology.

These suggestions to increase maize production relate to increasing the economic efficiency of maize production. This may be done through better use of existing inputs, increasing the quantity of variable inputs, and employing more productive cultivars of maize. Before any recommendations can be made, it is necessary to measure the relative economic efficiency of the different farm groups. Chapter III examines the various approaches to measuring economic efficiency.

Chapter III

ECONOMIC EFFICIENCY

3.1 INTRODUCTION

This chapter reviews alternative methods which have been used to evaluate economic efficiency. The last portion of the chapter is devoted to summarizing the profit function approach as developed by Lau and Yotopoulos.

Brown [1978] argued that agricultural production may be expanded by increasing output from current resources, increasing the quantity of variable inputs and employing more productive technology. This suggests that production can be increased by improving economic efficiency of farms. A firm is economically efficient if it minimizes cost or maximizes profit per unit of output. Economic efficiency is thus a function of price and technical efficiencies. Technical efficiency refers to output per unit of inputs. The higher the output per unit of inputs, the higher the technical efficiency. Differences in technical efficiency may be examined by measuring differences in technology. Price efficiency refers to the ability to find the optimum input mix. Under profit maximization assumptions, price efficiency is attained when the value of marginal product is equal to the marginal factor cost. This means that the farm with relatively higher profits is more price-efficient.

It is often assumed that a firm will employ the best possible techniques to achieve the highest level of economic efficiency. French [1977] argued that policy makers may prefer to keep some known inefficiencies rather than adopt new methods, if the prospective improvements in efficiency might reduce employment, decrease price competition, or lead to concentration of economic power. This implies that higher economic efficiency is just one of the objectives of society. Therefore, economic efficiency has to be weighed against other objectives of society.

3.2 EVALUATION OF ECONOMIC EFFICIENCY

In evaluating the economic efficiency of different sizes of farms, the literature in general is divided into several approaches and contrasting conclusions. French [1977] found that economic efficiency has been examined through (1) descriptive analysis of accounting data, or (2) statistical analysis of accounting data, or (3) the economic engineering approach. In reviewing the literature in agriculture, French [1977], and Hall and LeVeen [1978] identified limitations of the different approaches. Descriptive analysis of accounting data combines point estimates of average costs into classes for comparison. The limitations of descriptive analysis of accounting data are: (1) accounting differences make comparison difficult; (2) difficulty of separating factors that affect cost; and (3) absence of quantitative measure of parameters and functional relationships. Non-parametric economic engineering analyzes the relationship between optimum plan production costs and farm size. The problem is that many firms do not attain the most profitable input combination. Boles [1966] developed a linear programming algorithm to construct non-parametric production or cost functions from actual data. Under Bole's approach, the relative proximity of each farm to the production frontier is an index of technical efficiency. If cost functions are constructed, the proximity of each farm indicates economic efficiency. Even though economic engineering overcomes many of the problems in statistical and descriptive analysis, its use is limited because it does not evaluate actual farm behaviour.

Statistical analysis of accounting data estimates the parameters of production and cost functions using econometric techniques. French [1977] identified the limitations of statistical analysis. One problem is that different firms employ different accounting methods, thus it is necessary to convert all data to one system before conducting any statistical analysis. In addition, accounting data represent means (averages) of variables, thus it is difficult to obtain parameter estimates from such data. In multiple product firms, it is difficult to measure output. This means that it is difficult to measure the value added at every stage of production, thus output may be under- or over- estimated. Hall and LeVeen [1978] further argue that there are problems of consistency between theoretical definitions of production and cost functions, as to the maxima and minima. This is because the exact functional relationships are not known. Therefore, restrictive functional forms are often employed. In addition, statistical analysis requires adequate specification of the stochastic process generating data. If available data is not distributed according to the assumed distribution, then statistical analysis cannot be employed.

These approaches and their modifications have been used in both developed and less-developed countries. Controversy continues as to which farm size is the most efficient. Some studies have reported that small scale farmers are more efficient (price and/or technical efficiency) than large scale farmers (Lau and Yotopoulos [1971], Yotopoulos et al. [1976, 1973], Trosper [1978], World Bank [1982]). Other studies have argued that small scale farmers are as efficient as large scale farmers (Sidhu and Baanante [1979], Hall and LeVeen [1978], Garcia et al. [1982]). The third group of results on efficiency studies report that large farms tend to be more efficient than small farms (Khan and Maki [1979]). In addition, economies of size arguments offer explanation as to why large farms may be more efficient than small farms (Gould and Ferguson [1980], Doll and Orazen [1984], and Henderson and Quandt [1980]).

Depending on which of the reports is believed to be true, the policy prescriptions to raise agricultural production would differ. Even though the results are conflicting, information on economic efficiency is vital in policy evaluation and establishing performance among the different farm sizes. Woodsworth [1977] reported that production function estimation was the most popular approach to studying economic efficiency. A production function shows the maximum quantity of output which results from each combination of inputs, given technology, i.e., it summarizes efficient production possibilities. There are many specifications of production functions but the Cobb-Douglas functional form and its logarithmic transformations have been widely used. Woodsworth [1977] attributes the popularity of the Cobb-Douglas production function to: (1) convenience in interpreting elasticities of production, (2) minimal requirements of the degrees of freedom and (3) simplicity in computation. Assuming perfect competition and a Cobb-Douglas functional form, observations on the dependent variable measure the variation of output with inputs in fixed proportions. The residual term reflects entrepreneurial ability of the firm.

Woodsworth argued that the major limitations of the production function estimation relate to the great heterogeneity of the conditions from farm to farm, the absence of measurement of variables not included in the function, and the possibility of multicollinearity among the variables. In addition, the output and inputs are generated by a set of simultaneous relationships, thus they are dependent variables. Under these conditions, it is not correct to use a single regression equation to obtain parameter estimates. This is because parameter estimates may have large variances, i.e., inefficient parameter estimates.

Lau and Yotopoulos [1971] developed an alternative approach to the analysis of production. They used the profit function to measure and compare the economic efficiency of farms. This approach is usually referred to as the normalized restricted profit function and is based on the duality theory. Duality theory argues that for every production function, there is a corresponding profit function. The profit function is derived from the production function and expresses the maximized profit of a firm as a function of output price, variable input prices and the quantities of fixed factors of production, for a given technology. Garcia et al. [1982] suggested that if prices of variable inputs are constant, then profit may be expressed as a function of variable input expenditures and quantities of the fixed factors, i.e., quantities of variable inputs provide the variation necessary to obtain parameter estimates.

Lau [1979, 1971], Yotopoulos [1973], and Pudasaini [1981] reported that the profit function accounts for differences in the quantities of inputs used, is more flexible, and statistically better suited for estimation than a production function model. The advantages of profit function estimation arise from the following characteristics: (1) profit and factor demand functions are jointly estimated and thus generate consistent estimates, while a production function estimated by ordinary least squares may result in simultaneous equation bias and inconsistency; (2) input demand and output supply functions can be directly derived from the normalized restricted profit function without solving for the first order condition; (3) the impact of institutional characteristics can be introduced directly into the profit function; and (4) it takes into account differences in technical efficiency, price efficiency and permits testing for economic efficiency difference between groups.

O'Connor and Hammonds [1975] compared the results from the profit function model (a statistical approach) and the Farrell linear programming model (economic engineering) when investigating the relative technical, pricing and economic efficiencies of four groups of retail meat departments. They reported that the profit function model is superior to the Farrell linear programming technique. Some of the advantages of the profit function model cited are: (1) allowance for inter- and intra-group variations in prices, while other approaches allow only for inter-group; (2) estimation by ordinary least squares (even though Zellner's method is recommended), thus it employs standard statistical measures of goodness of fit which economic engineering cannot do; (3) it analyzes the actual farm behavior rather than the best practice; (4) it is less sensitive to outliers than the isoquant generated by the Farrell model; and (5) it is possible to obtain consistent input elasticities (for the production function) indirectly from the profit function (Lau [1971] and Yotopoulos [1973], O'Connor and Hammonds [1975]).

The profit function approach has been used in a number of studies in less developed countries. Lau and Yotopoulos [1972] estimated the profit and factor demand functions and showed how production function coefficients can be derived using data from Indian agriculture. Labor was used as the only variable factor, with capital and total area harvested as fixed factors. Using the same data, Yotopoulos and Lau [1973] tested for relative economic efficiency and isolated the causes of differences in efficiency between small and large farms. They found that both small and large scale farmers were price-efficient, and that small farms had superior technical efficiency. This implied that farms of less than ten acres were relatively more efficient. Khan and Maki [1979] applied the profit function model to derive values for technical and price efficiency parameters for large and small farms in the Sind and Punjab Provinces of Pakistan. The model included labor as the only variable factor, with land and capital being fixed inputs. They found that large farms are more economic-efficient than small farms.

Yotopoulos, et al. [1976] employed the restricted profit function to test for economic efficiency of farms in the Republic of China. The study was different in that the number of variable inputs was increased from one to four and also tested for structural change between successive cross section data. The variable inputs were total labor days, total animal work days, total hours of mechanical equipment and total quantity of fertilizer. The fixed factors were total quantity of fixed farm assets and total farm area harvested. They reported that agricultural producers in Taiwan were efficient producers within their environment. Sidhu and Baanante [1979] used the profit function to estimate economic efficiency for Mexican wheat cultivars in the Indian Punjab. Their variable inputs were labor, fertilizer and irrigation water. The fixed factors were land, capital and number of years of schooling. They reported that both small and large scale farmers attain technical and price efficiencies, that education of farm people contributes significantly to production, and that price of output influenced supply more than fertilizer price.

Pudasaini [1981] reviewed the use of the profit function to evaluate economic efficiency in agriculture and then employed the profit function to analyze the economic efficiency of tractorized and non-tractorized wheat farmers in Nepal. The variable inputs employed were hired labor, bullock hours, and fertilizer. The fixed input factors were land, family labor, capital, education, age and extension visits. Pudasaini reports that both farm groups were absolute allocative-efficient[14] and that tractorized farmers were technically more efficient, thus economically more efficient.

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[14] Lau and Yotopoulos [1971] used absolute efficiency to describe the ability to equate value of the marginal product to marginal factor cost, i.e., profit maximization. Relative efficiency was used to describe farms which do not attain absolute efficiency. Allocative efficiency is used interchangeably with price efficiency.

The profit function model has also been applied in developed countries. O'Connor and Hammonds [1975] used the profit function to measure relative economic efficiency for selected samples of retail meat departments. They reported that retail meat departments with central fabrication were more economic-efficient than those employing carcass-meat handling system. Trosper [1978] used the profit function to determine the American Indian relative ranching economic efficiency. Trosper found that American Indians and Whites in Montana, maximized profit to the same degree and that American Indians had greater technical efficiency than Whites.

In all of the studies employing the profit function approach, the division of farms into small and large is arbitrary. Doran [1985] proposed replacing the dummy variable by either a cumulative normal or logistic function. This approach makes specification of the cut off point unnecessary. The problem is that the model obtained requires nonlinear estimation. This approach is not necessary if farm groups have qualitatively different characteristics (e.g., oxen and tractors). If the criteria is continuous, then Doran's approach is needed.

Due to weaknesses inherent in the other approaches, the present study used statistical analysis of cross section data, and in particular the profit function, to analyze the relative economic efficiency of emergent and commercial farms in Zambia. If differences in economic efficiency exist, then an attempt will be made to identify the causes.

3.3 THE PROFIT FUNCTION CONCEPTUAL FRAMEWORK

This section presents important concepts behind the profit function model. Then it is shown how input demand functions can be derived from the production and profit function models, under the profit maximization assumption. Finally, this section shows how the profit function can be used to test for the relative economic efficiency of different groups of farmers.

Collinson [1983] argued that development is a continuum from hunting and gathering to full specialization in an exchange economy. He reported that the objective of subsistence farms is assured food supply. The major objective of large farms is assumed to be profit maximization. Since emergent farms are in between commercial and subsistence farms, their objectives include considerations of assured food supply and profit maximization. Assuming that assured food supply is a declining objective of emergent farmers, it is possible to use profit maximizing models to analyze production. In Zambia, the profit maximization assumption is justified based on the findings of the ILO [1981], Chambers and Singh [1981], World Bank [1982], Bessell and Iles [1976], Dodge [1977] and similar studies, from other less-developed countries, which argue that both emergent and commercial farmers respond to prices. As indicated earlier, economic efficiency is a function of technical and price efficiencies. The farms with higher technical efficiency and/or price efficiency make higher profits at every set of input and output prices. If farms have equal technical efficiency and unequal price (allocative) efficiency, then the group with higher allocative efficiency would make higher profits. If a farm group has higher technical efficiency and equal price efficiency with others, it would make higher profits. If farm groups have equal technical and price efficiencies but receive and/or pay different prices, their profit levels would be different. Lau and Yotopoulos, and Pudasaini argue that because the profit function considers these scenarios, it can be used to measure the relative economic efficiency, i.e., it can measure the price and technical efficiencies.

3.3.1 Technical Efficiency

A production function specifies the maximum output obtained from different levels of inputs, with a given technology. The production function is assumed to be homogenous of degree one in the variable inputs. Thus the marginal product is strictly positive ($\delta Y/\delta X>0$) and decreases monotonically ($\delta^2 Y/\delta X^2<0$). In addition, it is assumed that perfect competition exists in the input and output markets, and that there is instantaneous equilibrium in the input and output markets (Ferguson [1979], Henderson and Quandt [1980]).

Then, the production function may be specified as:

$$Y^i = A^i f(X^i_j, Z^i_t) \quad \ldots(1)$$

Where

i = 1,2 (1 = Emergent farms, 2 = Commercial farms)

A = technical parameter

X = variable inputs (j = 1, 2,...m)

Z = fixed inputs (t = 1, 2,...n)

Y = output

The technical parameter (A) includes farm group technical efficiency and may differ due to environmental factors, entrepreneurial ability and non-measurable fixed factors of production. Assuming the production functions of the two farm groups differ due to the technical parameters only, then there is a neutral shift[15] because factor ratios remain the same. Then, technical efficiency can be examined by measuring the difference between the two production functions. Two farm groups have the same technical efficiency if the technical parameter of group one equals the technical parameter of group two, i.e.,

$$A^1 = A^2$$

Therefore, a test of the hypothesis of equal technical efficiency has to be done on the technical parameter of the production function. This involves examining whether there are significant differences in technology of the two farm groups.

3.3.2 Price Efficiency

Profit maximization requires that the value of the marginal product (VMP)of each variable input be equal to the variable input price. The conditions for profit maximization are:

$$NR = PY - C X$$

$$\frac{\delta NR}{\delta x_j} = P \frac{\delta Y}{\delta x_j} - c_j \frac{\delta X}{\delta x_j} = 0 \qquad \ldots(2)$$

$$= PMPP_{x_j} = c_j$$

[15] Neutral shift refers to a change in the intercept of the function without altering the slope.

Where

NR = net revenue

P = price of the output

MPP_{x_j} = marginal physical product of j^{th} variable input

c_j = cost of j^{th} variable input

C = transpose of the vector of variable input costs.

X = diagonal matrix of variable inputs

x_j = j^{th} variable input

$PMPP_{x_j}$ = value of marginal product (VMP)

At this point, profit is maximized and price efficiency is attained.

Different farms respond to c_j in different proportions so that the ratio (k_j^i) is also different. The ratio (k_j^i) of the value of marginal product to the marginal factor cost is defined as follows:

$$PMPP_{x_j} = k_j^i \, c_j$$

$$k_j^i = \frac{PMPP_{xj}}{c_j} \qquad \ldots(3)$$

The proportionate response (k_j^i) reflects managerial and entrepreneurial ability of the farmer. Equal price efficiency occurs when farm groups are equally price-efficient with respect to all variable inputs. At this point ratios of the two farm groups are related as follows:

$$k_j^1 = k_j^2 = 1$$

Lau and Yotopoulos call this condition absolute price efficiency. Attainment of absolute price efficiency may not be possible if a farm does not have the resources necessary to purchase profit maximizing quantities of inputs. In addition the existence of some imperfect competition in the input and output markets may prevent a farm from maximizing profit. If farm groups are affected equally, the ratios may be related as follows:

$$k_j^1 = k_j^2 \neq 1$$

This means that the two farm groups are not absolute price-efficient but they have equal relative price efficiency. The two farm groups may have different price efficiencies if

$$k_j^1 \neq k_j^2$$

3.3.3 The Profit Function

The derivations of the profit function have been extensively covered by Lau [1976] and Lau and Yotopoulos [1972, 1971]. This section summarizes the material relevant to the study. To analyze the causes of differences in economic efficiency, Cobb-Douglas production functions for emergent and commercial farms are specified:

$$Y^i = A^i \prod_{j=1}^{m} (X_j^i)^{\beta_j} \prod_{t=1}^{n} (Z_t^i)^{\beta_t} \qquad \ldots(4)$$

Where

$i = 1, 2$ (1 = Emergent farms, 2 = Commercial farms)

$j = 1,2, \ldots m$, i.e., j^{th} variable input

$t = 1,2, \ldots n$, i.e., t^{th} fixed input

β_j = elasticity of output with respect to the j^{th} variable input

β_t = elasticity of output with respect to the t^{th} fixed input[14]

$$u = \sum_{j=1}^{m} \beta_j < 1$$

The two production functions are identical if:

$$A^1 = A^2 \quad \text{and} \quad k^1 = k^2$$

Therefore, by estimating these parameters, it is possible to test whether the two farm groups have equal economic efficiency.

Lau and Yotopoulos [1971, 1979] have argued that for each production function, there is a corresponding profit function. Assuming that farmers attempt to maximize profit, input and output prices are given, and the production function is concave in variable inputs, then the corresponding profit function of equation #4 is:

$$NR^* = A^{*i} \left[\prod_{j=1}^{m} (C_j^i)^{\beta_j^*} \right] \left[\prod_{t=1}^{n} (Z_t^i)^{\beta_t^*} \right] \qquad \ldots(5)$$

[16] There is no restriction on the sum of fixed input parameters because it reflects the standardized scale factor. This measures returns to scale. See section 3.3.5 (p.69). Yotopoulos and Lau [1973] argued that the restriction on the sum of variable input parameters (u) is needed because constant or increasing returns in variable inputs are inconsistent with profit maximization.

Where

$$A^{*i} = \left[A^{i(1-u)^{-1}} \left(1 - \sum_{j=1}^{m} \beta_j / k_j^i\right) \right] \left[\prod_{j=1}^{m} (k_j^i)^{-\beta_j (1-u)^{-1}} \right] \left[\prod_{j=1}^{m} \beta_j^{-\beta_j (1-u)^{-1}} \right]$$

The profit function is related to the production function (equation #4) as follows:

$$k^{*i} = \left(1 - \sum_{j=1}^{m} \beta_j / k_j^i\right) (1-u)^{-1}$$

$$u^* = \sum_{j=1}^{m} \beta_j^*$$

$\beta_j^* = -\beta_j (1-u)^{-1} < 0$, i.e., parameter estimates of variable inputs in the profit function.

$\beta_t^* = \beta_t (1-u)^{-1} > 0$, i.e., parameter estimates of fixed inputs in the profit function.

Therefore, these identities could be used to obtain production function elasticities and the technical parameter. If algebraic manipulations and parameter estimates (β_j^* and β_t^*) from the profit function are used, the production function elasticities could be obtained as follows:

$$\beta_j = -\beta_j^* (1-u^*)^{-1}$$

$$\beta_t = \beta_t^* (1-u^*)^{-1}$$

These estimates could provide information for determining the consequences of output price and input price change or combinations of the two. The cross elasticities could indicate which inputs are complements.

The profit function approach offers a way to measure relative technical and price efficiencies, separately. The profit function for each farm group is specified as follows:

Emergent farms:

$$NR^* = A^{*1} \left[\prod_{j=1}^{m} (c_j^1)^{\beta_j^*} \right] \left[\prod_{t=1}^{n} (z_t^1)^{\beta_t^*} \right] \qquad \ldots(6)$$

Commercial farms:

$$NR^* = A^{*1} (A^{*2}/A^{*1}) \left[\prod_{j=1}^{m} (c_j^2)^{\beta_j^*} \right] \left[\prod_{t=1}^{n} (z_t^2)^{\beta_t^*} \right] \qquad \ldots(7)$$

Specifying the profit function this way assumes that the production function for the two farm groups are identical up to a neutral efficiency parameter. This means that in equation #7, a varying intercept term captures the differences in behavior over farm groups and that the slope coefficient is constant. To linearize equations #6 and #7, natural logarithms were used.

$$\ln NR^* = \beta_0 \ln A^{*1} + \sum_{j=1}^{m} \beta_j^* \ln C_j^1 + \sum_{t=1}^{n} \beta_t^* \ln Z_t^1 \qquad \ldots(8)$$

$$\ln NR^* = \beta_0 \ln A^{*1} + \beta_1 \ln(A^{*2}/A^{*1}) + \sum_{j=1}^{m} \beta_j^* \ln C_j^2 + \sum_{t=1}^{n} \beta_t^* \ln Z_t^2 \qquad \ldots(9)$$

If production functions of the two farm groups are the same, then $A^1 = A^2$ and $k^1 = k^2$. The corresponding profit functions are identical if $A^{*1} = A^{*2}$ and $\beta_j^{*1} = \beta_j^{*2}$. Under these conditions, β_1 equals zero and $k^1 = k^2$. The group dummy variable (D_2) is defined as follows:

$$D_2 = \ln(A^{*2}/A^{*1}) = \ln A^{*2} - \ln A^{*1}$$

Because A^{*i} depends on the technical (A^i) and price (k^i) efficiencies from the production function, it is possible to use this relationship to test the null hypothesis of equal relative economic efficiency. This involves the use of a group dummy variable (D_2). The parameter estimate on the dummy variable (β_1) may be statistically examined to see if its value is significantly different from zero. If β_1 is significantly different from zero, then economic efficiencies of the two farm groups are not equal.

3.3.4 Input Demand Functions

Profit maximization is attained when the value of the marginal product is equal to the variable input price (marginal factor cost). Under the profit function approach, profit maximization is examined by testing whether there are significant differences between variable input coefficients in the profit function and the relevant input demand function for each farm group. Demand for an input is derived from demand for the commodity produced. Input demand functions are obtained by differentiating the profit function with respect to the price of each variable input (Yotopoulos et al. [1976]). If equation #5 is differentiated with respect to each variable input price, it is possible to obtain input demand functions:

$$X_j^i = \frac{\delta NR^{*i}}{\delta C_j^i} = -\beta_j^i$$

and then both sides are multiplied by $-C_j^i/NR^{*i}$

$$\frac{-C_j^i X_j^i}{NR^{*i}} = \frac{\delta \ln NR^{*i}}{\delta \ln C_j^i} = \beta_j$$

This becomes

$$\frac{-C_j^i X_j^i}{NR^{*i}} = (k_j^i)^{-1} (k^{*i})^{-1} \beta_j^{*i} \qquad \ldots(10)$$

But[17]

$$u = \sum_{j=1}^{m} \beta_j < 1$$

$$k^{*i} = (1 - \sum_{j=1}^{m} \beta_j/k_j^i)(1-u)^{-1}$$

[17] The restriction on (u) is necessary because decreasing returns to scale in variable inputs are consistent with profit maximization. If (u) is greater than and equal to one, the function is inconsistent with profit maximization.

Therefore

$$\frac{-c_j^i X_j^i}{NR*^i} = \frac{\beta_j^{*i} (1-u)}{k_j^{*i} (1-u/k_j)}$$

In the limit, k_j^* and k_j tend to one, and profit maximization is attained

$$\frac{-c_j^i X_j^i}{NR*^i} = \frac{\beta_j^{*i}(1-u)}{(1-u)} = \beta_j^{*i} \quad , \quad i=1,\ 2$$

k_j and $k_j^* \rightarrow 1$

Introducing dummy variables in the input demand functions

$$\frac{-c_j^i X_j^i}{NR*^i} = \beta_j^{*1} D_1 + \beta_j^{*2} D_2 \qquad \ldots(11)$$

Where

D_1 = dummy variable for emergent farms

D_2 = dummy variable for commercial farms.

Input demand functions differ between farm groups by a factor which depends on k_j^i . Because β_j^{*i} appears in the profit and input demand functions, they have to be estimated jointly in testing for differences in price and technical efficiencies. Joint estimation accounts for correlated error terms. Profit maximization (Lau and Yotopoulos call this absolute profit) requires that corresponding variable input parameters in the profit and input demand functions be equal. This occurs when $k_j^i = 1$ and $k_j^{*i} = 1$. This implies that for:

Emergent farms:

$$\beta_j^{*2} = \beta_j^*$$

Commercial farms:

$$\beta_j^{*1} = \beta_j^*$$

However, farms may not achieve absolute price efficiency. If so, the appropriate concept is relative price efficiency. Relative price efficiency occurs if $k^1 = k^2 \neq 1$. Then, the appropriate test for the hypothesis of equal relative price efficiency is:

$$\beta_j^{*1} = \beta_j^{*2}$$

Recall the relationship (from the production functions) that exists between two farm groups which have attained profit maximization to the same degree

$$A^1 = A^2 \text{ and } k^1 = k^2$$

The corresponding profit functions are related as follows:

$$A^{*1} = A^{*2} \text{ and } \beta_j^{*1} = \beta_j^{*2}$$

If so, the two profit functions are the same. Therefore, by jointly testing for the equality of economic and price efficiencies, it is possible to test for technical efficiency. Failure to reject the joint hypothesis implies that the two farm groups have equal technical efficiency. Since relative price efficiency can be tested separately, it is an indirect way of testing for equal technical efficiency. Because the relative price efficiency component is included, the conclusion reached should not contradict the individual test results.

3.3.5 Returns to Scale

To deal with a dual agriculture (emergent and commercial farms) that has developed over time, there is need to determine the farm group to focus on. The decision depends on how farm groups respond to a proportional increase in all inputs. If output increases by a smaller proportion, then the production function displays decreasing returns to scale. If output responds by a greater proportion than inputs, then increasing returns to scale exist. Constant returns to scale occur if both inputs and output increase by the same proportion. Examining these concepts would assist in determining the farm size to focus on.

Assuming a production function of homogeneity degree k, the test for returns to scale is derived as follows (Yotopoulos and Lau [1973]):

$$\frac{k-1}{k} \sum_{j=2}^{m} \beta_j^* + \frac{1}{k} \sum_{t=1}^{n} \beta_t^* = 1 \qquad \ldots(12)$$

$$\sum_{t=1}^{n} \beta_t^* = k-(k-1) \sum_{j=2}^{m} \beta_j^*$$

If:

$k > 1$, then, $\sum_{t=1}^{n} \beta_t^* > 1$. This is the case of increasing returns to scale.

k = 1, then, $\sum_{t=1}^{n} \beta_t^* = 1$. The production function exhibits constant returns to scale.

k < 1, then, $\sum_{t=1}^{n} \beta_t^* < 1$. This is an indication of decreasing returns to scale.

Therefore, the test to be used for constant returns to scale is

$$\sum_{t=1}^{n} \beta_t^* = 1$$

3.4 HYPOTHESES TESTING

Using equations #9 and #11, it is possible to test for the significance of hypotheses identified in section 1.3, Chapter I. After estimation of parameters, F-statistics are computed. The decision rule involves rejecting the null hypothesis if observed F is greater than critical F. On the other hand, one fails to reject the null hypothesis if observed F is less than critical F.

3.4.1 Equal Relative Economic Efficiency

Relative economic efficiency is important in production for it indicates the loss or gain from policy changes. Therefore, to examine the null hypothesis of equal relative economic efficiency, the F-statistic would be used to test whether the dummy variable parameter (β_1) is significantly different from zero.

$$H_o: \beta_1 = 0$$

$$H_A: \beta_1 \neq 0 \qquad \ldots(13)$$

If β_1 is significantly different from zero, then the economic efficiencies of emergent and commercial farmers are not equal. By rejecting the null hypothesis, the alternative hypothesis is accepted.

Failure to reject the hypothesis (#13) implies that the two farm categories have the same economic efficiency. Therefore, efforts have to be made to explain the observed economic efficiency. If the two farm groups are not equally technical-efficient, then production should be increased by improving the least technical-efficient farm group. If equality of the relative price efficiency is rejected, then expanded extension services should focus on the least price-efficient farm group. These imply that observed economic efficiency should be explained by examining the null hypotheses of equal price and technical efficiencies.

3.4.2 <u>Equal Relative Price Efficiency</u>

Efficient resource allocation is required under profit maximization. To compare price efficiencies of the two groups, the F-statistic should be used to test whether the ratio of observed variable input bill to the variable profit is significantly different. The test is based on parameter estimates of derived input demand functions:

$$H_o: \beta^{*1}_j = \beta^{*2}_j \qquad \ldots(14)$$
$$H_A: \beta^{*1}_j \neq \beta^{*2}_j$$

This test compares the allocative efficiency of the two farm groups for each variable input. If the null hypothesis is rejected for any one of the variable inputs, then the two farm groups do not efficiently allocate variable inputs to the same degree. Then, the farm group with greater price efficiency utilizes the variable inputs better than the other. Failure to reject the null hypothesis of equal relative price efficiency implies that all farm groups maximize profit to the same degree, with respect to variable inputs. Equal relative price efficiency implies that setting maximum limits on access to certain resources (e.g., credit) would not result in a net loss of allocative efficiency.

3.4.3 Equal Relative Technical and Price Efficiencies

Economic efficiency consists of technical and price efficiencies. Farm groups may be equally economic efficient without being equally technical or equally price-efficient. Trosper [1978], Yotopoulos and Lau [1973] have indicated that if price inefficiency exists, it creates an identification problem for tests of technical efficiency. They recommend a simultaneous test for technical and price efficiencies. Therefore, the test for economic efficiency must be conducted through the profit function dummy variable.

Because the price efficiency hypothesis can be tested separately and recall that the production function identities are:

$$A^1 = A^2 \text{ and } k^1 = k^2$$

and the corresponding profit function identities are:

$$A^{*1} = A^{*2} \text{ and } \beta_j^{*1} = \beta_j^{*2},$$

then a test for equality of economic efficiency is a test for equality of technical efficiency between the two farm groups. This implies that the null hypothesis of equal relative technical and price efficiencies is:

$$H_o: \beta_1 = 0 \qquad \ldots(15)$$
$$\beta^{*1}_j = \beta^{*2}_j$$
$$H_A: \beta_1 \neq 0$$
$$\beta^{*1}_j \neq \beta^{*2}_j$$

Therefore, by jointly testing for equal relative economic and price efficiencies, it is possible to test implicitly for equal relative technical efficiency. Failure to reject hypothesis #15 implies that the two farm groups are equally economic-efficient, i.e., price and technical efficiencies are equal. This means that if a new policy imposes maximum limits on access to some resources, it would not lead to overall loss in economic efficiency and may only serve to redistribute profit from one group to another.

3.4.4 Constant Returns to Scale

The concept of returns to scale examines output response to proportionate increase in all inputs. To examine whether the two farm groups exhibit constant returns to scale, the F-statistic should be used to test the following hypothesis:

$$H_o: \sum_{t=1}^{n}\beta^*_t = 1, \qquad (t= 1,2,\ldots n) \qquad \ldots(16)$$
$$H_A: \sum_{t=1}^{n}\beta^*_t \neq 1$$

Failure to reject the hypothesis of constant returns to scale implies that a proportionate increase in all inputs results in output increasing by the same proportion. Constant returns to scale among the two farm groups would imply that no one scale of operation is more efficient. Therefore, efficient farms can occur in a wide range of sizes. If the null hypothesis is rejected , then the two farm groups do not operate under constant returns to scale. This means that the two farm groups may be operating under increasing or decreasing returns to scale. By testing the null hypothesis for increasing and decreasing returns to scale (subsection 3.3.5, p.69), it is possible to establish the response to proportionate increase of all inputs.

The results arising from this section should indicate the direction of policy. By conducting these tests, it is possible to infer whether a given policy would lead to economic efficiency loss. However, relative efficiency is not the only factor that determines final policy. In practice, policy makers are also concerned about equity and political considerations. Chapter IV utilizes the concepts summarized in Chapter III to develop a model for this study.

Chapter IV

ESTIMATION PROCEDURES

This chapter specifies the model assumptions, the model to be estimated, the a priori economic theory and the hypotheses to be tested.

4.1 MODEL ASSUMPTIONS

1. Farmers are price takers.
2. Farmers maximize profit.
3. The farm's maize production function is concave in variable inputs: hired labor, fertilizer and other cash expenditures.
4. In the short run the fixed inputs are family labor, non-land capital, area harvested and education per family.

These assumptions approximate the conditions existing in Zambia. The farmer's decision variables are quantities of output, hired labor, fertilizer, and other cash expenditures. The price of output, prices of variable inputs and quantities of fixed inputs are predetermined (i.e., they are exogenous variables). This implies that they cannot be changed by an individual farmer in the short run. Farmers choose the output and input levels which maximize profit. This means that the level of output and inputs are not predetermined variables. The output, hired labor, fertilizer and other cash expenditures are jointly dependent variables. Because short run profit is total revenue (TR) minus total variable costs (TVC), it is also a jointly dependent variable.

Profit is a function of the prices of variable inputs and the quantities (levels) of fixed inputs. By differentiating the profit function, quantities of output and inputs become functions of prices. A problem arises if there is no cross section variation in the prices of variable inputs and output. This means that it is not possible to obtain parameter estimates of these variables. However, if the quantities of output and inputs used vary across farms, then short run profit may be expressed as a function of variable input expenditures and the quantities of fixed factors. Garcia et al. [1982] argued that where a data base only provides information about expenditures on variable inputs, the profit function may be rewritten in terms of both variable input prices and cash expenditures, without violating hypotheses testing procedures. Based on data available, profit is specified as a function of variable input expenditures and quantities of fixed inputs. Specified this way, profit increases in variable and fixed inputs. If the variable is mis-specified or the price variation dominates quantity variation, the parameter estimate may be negative. If quantity variation dominates price variation, then the estimated parameter could be positive.

Some unknown exogenous factors may affect profitability of a farm. Their influence is captured through the profit function error term. Error terms in input demand functions account for differences in ability to maximize profit and/or divergence between expected and realized prices.

4.2 MODEL SPECIFICATION

The approach is to compare actual profit functions of two farm groups, given output and input prices, and quantities of measurable fixed inputs. The model is specified as follows:

$$\ln NR^* = \beta_0 \ln A + \beta_1 D_2 + \beta_2 \ln NWL + \beta_3 \ln NP_2F + \beta_4 \ln NCE + \beta_5 \ln FAM + \beta_6 \ln S + \beta_7 \ln H + \beta_8 \ln YR + e_1 \quad \ldots(17)$$

$$-WL/NR = \beta_9 D_1 + \beta_{10} D_2 + e_2 \quad \ldots(18)$$

$$-P_2F/NR = \beta_{11} D_1 + \beta_{12} D_2 + e_3 \quad \ldots(19)$$

$$-CE/NR = \beta_{13} D_1 + \beta_{14} D_2 + e_4 \quad \ldots(20)$$

Where

NR^* = total revenue (TR) minus total variable cost (TVC) normalized by output price, i.e., $(TR - TVC)/P_1$

NR = net revenue

A = technical parameter of the profit function

D_1 = emergent farm dummy variable ($D_1 = 1$ if emergent farm, $D_1 = 0$ if not emergent farm).

D_2 = commercial farm dummy variable ($D_2 = 1$ if commercial farm, $D_2 = 0$ if not commercial farm).

W = average daily wage for hired labor (K/day)

L = total number of days of hired labor.

WL = total wage bill for hired labor.

CE = total other cash expenditures on other variable inputs.

FAM = family labor days available.

P_2 = price of fertilizer paid by the farmer (K/50Kg bag).

F = total number of 50 Kg bags of fertilizer used.

P_2F = total fertilizer bill (K).

S = total amount of service flow from non-land capital[18]

H = area of maize harvested (acres).

YR = average number of years of schooling per family.

P_1 = price of maize (K/90 Kg bag).

e_i = error terms to account for unmeasurable exogenous factors.

β_i = parameters to be estimated.

NWL = total hired labor cost normalized by the price of maize per bag (WL/P_1).

NP_2F = total fertilizer cost normalized by the price of maize (P_2F/P_1).

NCE = total other cash expenditures normalized by the price of maize (CE/P_1).

The dummy variable (D_2), in the profit function, measures the difference in economic efficiency between the two farm groups. When equations #18, #19, and #20 are estimated with no intercept, the parameters obtained are relative factor shares. Because, the dummy variables take on the values of either one or zero, they may be correlated, i.e., multicollinear to some degree. This problem may affect the reliability of the tests.

[18] The discussion of the measurement of service flow is based on the concept developed by Yotopoulos [1967]. It is discussed in section 5.2.6 (p.93 to 96).

However, equations #18, #19, and #20 may be reparameterized in terms of one dummy variable. If these equations are estimated with an intercept, the included dummy variable measures the difference between relative factor shares. Using this difference and the intercept, it is possible to obtain parameters for D_1 and D_2 in each input demand function. By using one dummy variable, the possibility of creating multicollinearity between D_1 and D_2 is reduced.

4.3 MODEL ESTIMATION AND TESTING

The four equations (#s 17 to 20) are related because profit maximization (absolute efficiency) requires that parameter estimates of corresponding variable inputs in the profit and input demand functions be equal. In addition, error terms in different equations may reflect common unmeasurable or omitted factors. The other reason is that output and inputs are simultaneously related, thus they are jointly dependant variables. Therefore, it is possible to assume that the correlation of error terms in different equations is non-zero. Since the model is based on cross section data, the correlation is usually called contemporaneous correlation. Because the two farm groups are assumed to make independent production decisions, the covariance of error terms across groups is zero.

Under these assumptions, ordinary least squares (OLS) parameter estimates would be consistent and unbiased. However, OLS will not yield efficient parameter estimates. This is because endogenous variables appear on the right hand side of the profit function. This produces dependence between variables on the right hand side of the equation and the error term. Therefore, it is necessary to account for the correlations across equations. The appropriate estimation procedure is Zellner's method. Judge et al. [1980, p.247] summarized Zellner's estimater. Profit and input demand functions could be represented in matrix form:

$$\underbrace{\begin{bmatrix} Y_1 \\ Y_2 \\ \vdots \\ Y_m \end{bmatrix}}_{Y} = \underbrace{\begin{bmatrix} X_1 & & & \\ & X_2 & & \\ & & \ddots & \\ & & & X_m \end{bmatrix}}_{Z} \underbrace{\begin{bmatrix} \beta_1 \\ \beta_2 \\ \vdots \\ \beta_m \end{bmatrix}}_{\alpha} + \underbrace{\begin{bmatrix} e_1 \\ e_2 \\ \vdots \\ e_m \end{bmatrix}}_{E}$$

Where

Y = matrix of dependant variables in all equations

X = matrix of exogenous variables in all equations

β = matrix of parameter estimates in all equations

e = matrix of error terms in all equations

or

$$Y = Z\alpha + E$$

Then, Zellner's estimater is:

$$\alpha = [\ Z'(V^{-1}I)Z\ ]^{-1}Z'(V^{-1}I)Y$$

Where

I = identity matrix

V = variance-covariance matrix

Therefore, Zellner's method utilizes generalized least squares (GLS) approach. To employ the GLS procedure, an estimate of the disturbance variance (S) is used. The estimate is obtained as follows:

1. Each equation is estimated by using ordinary least squares

$$b = (X_i'X_i)^{-1}X_i'Y_i$$

2. Residuals from each equation are obtained as follows:

$$e_i = Y_i - X_i b_i$$

Then

$$S = T^{-1}e_i'e_i$$

Where

T = number of observations

3. The estimate of the variance-covariance matrix (V) is

$$V = V(e) = \begin{bmatrix} S_{11}I & S_{12}I & --- & S_{1M}I \\ S_{21}I & S_{22}I & --- & S_{2M}I \\ \vdots & \vdots & & \vdots \\ S_{M1}I & S_{M2}I & --- & S_{MM}I \end{bmatrix}$$

$$= \begin{bmatrix} S_{11} & S_{12} & S_{1M} \\ S_{21} & S_{22} & S_{2M} \\ \vdots & \vdots & \vdots \\ S_{M1} & S_{M2} & S_{MM} \end{bmatrix} I$$

The estimates of covariances of residuals across equations are used to increase the efficiency of parameter estimates. In addition, this approach uses information provided by explanatory variables that appear in the system but are excluded from the particular equation. Therefore, the efficiency of parameter estimates increases when all equations are viewed as a single large equation. Efficiency is further increased if the explanatory variables in the different equations are not highly correlated (i.e., no multicollinearity). O'Connor and Hammonds [1975] argued that pooling equations increases the risk of creating multicollinearity. They note that this may create testing problems as standard errors and covariances tend to increase. The net effect is bias towards acceptance of the null hypothesis. Parameter estimates are obtained through generalized least squares.

The F-statistic is used to test hypotheses about coefficients. It compares the restricted and unrestricted residual sums of squares. Judge et al. [1980] noted that joint tests are preferable to individual t-tests on the coefficients. Cassidy [1981, p.249] noted that for one degree of freedom, the square root of the F-statistic is the two sided t-statistic, i.e., $t=(F)^{0.5}$. The F-statistic is defined as follows:

$$F = \frac{R^2}{1 - R^2} \cdot \frac{MT - \Sigma_i K_i}{\Sigma_i K_i - M}$$

Where

$$R^2 = 1 - \frac{E'(V^{-1}I)E}{Y'(V^{-1}D_T)Y}$$

$D = I - jj'/T$ is an idempotent transformation matrix that expresses variables in terms of deviations around their respective means.

$E = Y - ZV$, i.e., generalized least squares residuals

$j = (1,1,\ldots,1)$

I = identity matrix

K = number of unknown parameters

M = number of equations.

T = number of observations

If the F-statistic is used to examine goodness of fit, it tests whether coefficients in the system are zero, with the exception of intercepts in each equation. On the other hand, the R^2 statistic measures the variation around the unweighted mean of that equation.

4.4 A PRIORI ECONOMIC THEORY

Lau and Yotopoulos [1972, 1971] reported that the profit function decreases in variable input prices (i.e., variable input price parameters are expected to be negative) and the function is convex (i.e., second derivative is ≥ 0). As variable input prices rise, profit decreases. Since there is no cross section variation in prices of variable inputs, variable input expenditures per farm are used as independent variables. If expenditure data is used, both price and quantity effects are captured. This means that increases in variable input expenditures could result from increased prices and/or quantity of inputs. Fortunately, prices are the same in cross section data (except for transport cost differences). Therefore, price increases are not sources of expenditure change. Up to a certain limit,[19] an increase in the quantity of variable inputs would increase yield. This may result in higher profits, other factors remaining constant. Under these conditions, parameter estimates of variable inputs may be positive. However, if the price variation dominates the quantity variation, the parameter may be negative. The profit function is assumed to increase with all fixed inputs, i.e., fixed input parameters are expected to be positive. Increase in family labor and service flow from non-land capital assure timely implementation of all cultural practices, and thus increase total yield and profit. Education may help improve management of the farm by raising price efficiency. This arises from improved ability to acquire and process information, thus the farmer would allocate resources more efficiently. Better managers produce higher yields. Therefore, all fixed factor parameters are expected to be positive.

4.5 HYPOTHESES TESTED

Economic efficiency is a function of technical and price efficiencies. After estimation of parameters, the F-statistic is used to test the null hypotheses of equal economic, price, and technical efficiencies. In addition, this section also specifies how to test for the existence of constant returns to scale among emergent and commercial farms.

[19] If used in very large quantities, some inputs become toxic to the maize plant, and thus decrease yield.

4.5.1 Equal Relative Economic Efficiency

This involves testing whether profit function intercepts (p.65) are significantly different.

$$H_o : \beta_o^1 = \beta_o^2$$
$$H_A : \beta_o^1 \neq \beta_o^2$$

The difference between the two profit functions is measured through the dummy variable parameter (β_1), thus the null hypothesis is

$$H_o : \beta_1 = 0$$
$$H_A : \beta_1 \neq 0$$

If β_1 is significantly different from zero, then the economic efficiencies of emergent and commercial farmers are not equal.

4.5.2 Equal Relative Price Efficiency

The test involves examining whether there is a significant difference between parameters of input demand functions for a given input. Therefore, this study examines whether the ratio of observed variable input expenditures to variable profit is significantly different among emergent and commercial farms. The null hypotheses are:

for labor:

$$H_o : \beta_9 = \beta_{10}$$
$$H_A : \beta_9 \neq \beta_{10}$$

for fertilizer:

$$H_o : \beta_{11} = \beta_{12}$$
$$H_A : \beta_{11} \neq \beta_{12}$$

and for other cash expenses:

$H_O : \beta_{13} = \beta_{14}$

$H_A : \beta_{13} \neq \beta_{14}$

Rejecting any one of these tests implies that the two farm groups do not have the same relative allocative efficiency, with respect to the particular variable input. Failure to reject the null hypothesis implies that the two farm groups maximize profit to the same degree.

4.5.3 Equal Relative Technical and Price Efficiency

Economic efficiency is a function of technical and price efficiencies. A joint test for equal relative economic and price efficiencies is used to examine the null hypothesis of equal relative technical efficiency.

$$H_0 : \quad \beta_1 = 0$$
$$\beta_9 = \beta_{10}$$
$$\beta_{11} = \beta_{12}$$
$$\beta_{13} = \beta_{14}$$

Since the null hypotheses of equal relative economic and price efficiencies can be tested separately, this tests for technical efficiency. If the null hypothesis is not rejected, it implies that the two farm groups have equal relative technical efficiency. If the null hypothesis is rejected, then the technical efficiencies of the two farm groups are not the same.

4.5.4 Economies of Scale

To examine production response of the two farm groups to proportionate increase in all inputs, this study tests for the existence of constant returns to scale.

$$H_O : \beta_5 + \beta_6 + \beta_7 + \beta_8 = 1$$

$$H_A : \beta_5 + \beta_6 + \beta_7 + \beta_8 \neq 1$$

If the sum of parameters estimates of fixed inputs equal one, then a proportionate increase in all inputs produces a proportionate increase in output. Therefore, failure to reject the null hypothesis implies that constant returns to scale are present. Because the profit function approach accounts for differences in resources employed, it is possible to jointly test for constant returns to scale.

This chapter identified variables in the model and testing procedures to be employed. Chapter V describes how data were obtained and processed.

Chapter V

SOURCES OF DATA

5.1 INTRODUCTION

The purpose of the survey was to gather data to determine the relative economic efficiency of different farm groups. The survey was completed in 1986. A questionnaire was administered by interviewing farmers in three districts (Serenje, Mkushi, and Kabwe) of Central Province. The sample consisted of 125 maize farms.

Initially, the sample was divided according to the source of power. The result was three farm groups: small scale, using hand hoe; emergent, using oxen; and commercial, using tractors. Small scale farmers employ their own labor and hand tools to meet family food needs and occasionally sell some of the produce. They usually attain low yields and minimal or no income. The problem is that the logarithmic profit function cannot transform negative numbers. Based on the results from pretesting the questionnaire, it became apparent that small scale farmers rarely produced a marketable surplus. This made data collection from small scale farmers unnecessary. Data were collected from emergent and commercial farmers in Central Province (Figure 2, p.10).

Data were based on the farmer's memory, for most farmers do not keep farm records. A few commercial farmers kept a list of expenses. Most farmers relied upon their experience and memory.[20] Therefore, data collected refers to average use of inputs (over the years) rather than an actual amount of expenditures. In some cases, farmers were not able to recall detailed information, e.g., number of days worked by hired and family labor.[21] However, it was possible to recall information on most expenses (especially major expenditures) for inputs and activities. Therefore, most of the information gathered consist of expenditures.

5.2 DATA COLLECTED

Information collected included maize production, input purchases, sales records, inventory records, labor and other input utilization, and description of all equipment and oxen used to produce maize.

5.2.1 Maize Production and Pricing

The output of maize was measured in 90 kilograms (Kg) bags. Total output included the number of bags sold, the number of bags stored for future consumption, the number of bags already used by the family, and the number of bags used as gifts to friends and relatives.

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[20] Because many farmers cannot recall all information needed to estimate costs of production, the results may be affected. This observation may be valid on commercial farms where many inputs are used. If farmers underestimate costs, profits may be exaggerated and vice versa. This study assumes that farmers use experience to estimate quantities of inputs to apply in a given year and that the ability to recall information is the same across farm groups.

[21] Under these conditions, questions could be raised about the applicability of econometrics. In this study the focus is on the efficiency of production practices which have been developed over a long period. Thus, estimates based on memory could provide the necessary information.

The price of maize is controlled by the government and a uniform price is paid to all farmers throughout the country. However, farmers have to pay for transport costs to the local marketing depot. Therefore, net price realized for maize may be different for each farmer. The problem is that most farmers estimated transport costs based on government controlled rates, thus only distance to marketing depots varied.

5.2.2 Labor

Labor is a very important input in maize production. In this study hired labor is measured in adult equivalent days used on the maize enterprise (Table 6). Adult days are easy to remember and hired workers are paid based on the number of days worked. However, some key employees are kept on the payroll on an annual basis. To lower labor costs, permanent workers are usually involved in off season jobs, e.g., machinery overhaul and general maintenance.

Information was obtained on the number of hired workers, days worked, and wages paid. Where hired labor was used and the estimate of wages not available, wages paid by nearby farmers or the average for the district are used. The wages paid include board and room, where available.

Family labor provides a significant portion of labor and is measured in adult equivalent days available. Although family labor has an opportunity cost, in the short run it can be treated as a fixed input. In addition, short run alternative uses of family labor are limited. In this study, family labor is treated as a stock variable. Treating family labor as a stock variable eliminates the need to value it. It is

TABLE 6

Converting Labor to Adult Equivalent Days

Labor Class	Age	Adult Equivalent Day
Small child	Less than 7	0.00
Big child*	7 - 14	0.50
Adult	15 - 64	1.00
Adult	65 Or over	0.50

*For school going children, assume that they supply (1/3) one third of the adult equivalent day, within the age class.

difficult to obtain an estimate of the time actually worked by farmers who reported to be full time, thus this study assumed that farmers work six days per week. However, information was obtained on sex, age, education of family members and number of months spent on the maize enterprise. The ages of family members differ. Therefore, family labor is aggregated using adult equivalents days (Table 6).[22] The weights are based on the following assumptions: (1) productivity is positively and later negatively related with age, (2) no difference in the productivity of adult women and men. An attempt was made to account for school children who contribute only during holidays, weekends and after school.

[22] The weights used to convert labor to adult equivalent days may be changed without affecting the results, so long as they do not vary between the two farm groups. This study assumes that productivity labor, within a given class, is the same.

5.2.3 Fertilizer

In Zambia, maize fertilizer is sold in 50 kilogram bags and consists of urea and compound D. Compound D is used as basal dressing and consists of 10% nitrogen (N), 20% phosphate (P_2O_5) and 10% potash (K_2O). Urea is used as top dressing and consists of 46% nitrogen. Data were collected on either the total number of bags per farm or total number of bags per acre of each type of fertilizer.

The government controls the price of fertilizer and farmers pay a uniform price for a 50 Kg bag of fertilizer at every depot. However, farmers have to pay transport costs to the farm. Therefore, the net price paid for a bag of fertilizer is different. Since estimates of the cost of transport were based on government controlled rates, there is no difference in the rate per kilometer per bag.

5.2.4 Other Cash Expenses

Other cash expenses involved in maize production are on seed, chemicals, fuel, repair and maintenance, empty maize bags, and tractor and oxen hire. Chemicals refer to herbicides and insecticides. The values of these items are aggregated to produce a total of other cash expenses. Data on individual expenditures is weak, thus most of the information refer to cash expenditures.

5.2.5 Land

In this study, land is measured in acres harvested. Where farmers were not sure of the area, it was possible to infer size of the field from the quantity of seed used. In some cases farmers planted maize on several fields. If so, data from the different fields were aggregated (assuming similar conditions exist). Zambian law does not allow sale of land (for it is owned by the state) and only permits sale of improvements, thus valuation of the land is not reliable. Therefore, valuation of permanent improvements was estimated where possible.

5.2.6 Non-Land Capital

Fixed non-land capital refers to machinery, equipment, buildings, improvements and oxen at the beginning of the 1985/86 season. Emergent farmers use small quantities of capital. Farm machinery is primarily used on commercial farms. On emergent farms, machinery use is confined to hired services because of high initial costs of farm machinery, and shortage of maintenance and repair facilities. Under such conditions, machinery use is economically feasible on commercial farms. An attempt was made to obtain numbers, ages, initial values, current values and replacement cost of tools. It was easy for farmers to remember the initial value. Current values could not be relied upon because of the tendency of farm machinery to appreciate and the continually rising replacement costs of new machinery.

Livestock was included because of its importance on emergent farms. Oxen is a source of power, thus it was the livestock class included in the survey. Some farmers hire oxen for it is cheaper than tractors and tractors are not available everywhere. Trained oxen were valued at current market price. This is because most of the farmers refused to consider the possibility of selling their oxen. An attempt was made to determine the type of work performed and the number of oxen days needed to complete the task. Farmers could not always remember the number of oxen days, thus only estimates are available.

Most of the inputs classified under non-land capital, provide services over a period of time. Seasonal service flow is approximated by the rental value multiplied by days or units worked. In the absence of rental rates and data on units worked, the proxy often used is capital stock (gross or net of depreciation). The problem is that data on net capital stock are not observable. Yotopoulos [1967] criticized this practice and suggested an alternative approach. This involves estimating service flow from the original gross value of the durable asset. Since farmers could easily remember the initial expenditures on durable assets, service flow was used to measure non-land capital.

In Zambia, obsolescence is not an important issue because most farmers retain their old machinery and equipment, and do everything possible to keep them working. This study assumed that assets do not deteriorate and have no salvage value. Therefore, for machinery and equipment, service flow is estimated as follows:

$$R = rV_0^{T^i}/(1-e^{-rT^i})$$

Where

R = constant annual service flow from the i^{th} asset

V_o = present (undepreciated) market value of the i^{th} asset

T^i = life expectancy of the i^{th} asset

r = discount rate

Many small scale farmers depend on oxen as a source of power. Yotopoulos [1967] suggested a different formula for estimating service flow from live durable (oxen) assets:

$$R_{it} = rV_{it} - (V_{i_{t+1}} - V_{it})$$

Where

R_{it} = current service flow from the i^{th} asset

V_{it} = current market value of the i^{th} asset

t = 1,....,T

r = discount rate

In this study, information obtained from the survey could not permit estimation of the second term. Therefore, this study assumes that service flow from a live asset is proportional to capital stock (rV_{it}).

Discount rates are chosen based on the opportunity cost. In the past, the capital market was controlled by the government.[23] Therefore, commercial interest rates did not reflect the opportunity cost. During

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[23] In 1985, the government stopped controlling interest rates as one of the IMF conditions. By 1986, interest rates rose to about 30 percent. In 1987, the government discontinued the IMF program and reimposed interest rate controls.

the survey period, the government de-regulated interest rates. The result was that interest rates rose to reflect the opportunity cost of capital (25%). Life expectancy of assets is based on the manufacturer's projection and the farmer's experience. The service flow per acre is estimated for each asset and the sum of all assets is the durable capital input.

5.2.7 Interest Rate

Capital consists of liquid capital and fixed capital. The sources major sources of capital are equity and/or credit. The cost of borrowing for commercial farmers was the rate charged by commercial banks (25%). This is because most commercial farmers obtain credit from private commercial banks. Most emergent farmers obtain credit from the Agricultural Finance Company (AFC), a government organization. Therefore, emergent farm interest rate was the rate charged by AFC (20%).

5.2.8 Education

Education is important in the adoption of new technology. Appropriate use of new technology, other things equal, produces higher yields and profits. Family members take part in decisions involving maize production. Data were collected on the number of years of formal schooling of each family member involved in maize production. The average number of years of schooling per family was used as a proxy for education.

5.2.9 Profit

Farmers have several competing goals.[24] The World Bank [1984a, b] reported that even though profit maximization is not the only goal, most farmers consider it to be very important. The literature has several definitions of profit: net cash income, i.e., gross income minus cash costs; net farm income, i.e., net cash income minus depreciation; operator income, i.e., net farm income minus interest on investment; and entrepreneurial income, i.e., operator income minus opportunity cost of operator's management. Opportunity cost is approximated by the market rate of return. In the long run, profit must be large enough to compensate the fixed factors. In the short run, revenue has to cover all variable costs of production for a farm to remain in business. For this study, net cash income is the desired definition of profit. Unless net cash income is positive, the farmer has to find alternative sources of funds to continue in business. Positive net cash income is crucial, for modern farming depends on credit. Most banks require full repayment of their seasonal loans before a farmer can qualify for additional credit.

5.2.10 Difficulties

Some difficulties were encountered. A few farmers would not willingly release data on profitability. Among emergent farmers, it was difficult to convince them that information gathered could assist in the formulation of future policy and that all farmers would gain from the

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[24] Collinson [1983, p.21] argued that the major objective of small scale (e.g., emergent) farms is assured food supply and that profit maximization becomes important as the farmer increases dependency on the market. In addition, reduction of the fluctuations of profit or food supply could be a secondary objective.

survey. This is because other programs or studies usually reward participating farmers.[25] Even among commercial farmers, records are not kept on individual enterprises. Therefore, it was possible to obtain only estimates.

Government programs and intervention have distorted some of the available data. In the 1985/86 season, several economic reforms were initiated. Jansen [1986] reports that producer prices were increased substantially. The study found that competition among marketing organizations (National Agricultural Marketing Board and Cooperatives) encouraged early delivery of inputs and collection of maize. In addition, the rains were good. These factors combined to produce substantially higher yields for all farmers. Therefore, the findings may not reflect the usual conditions.

5.3 DATA PROCESSING

Results from the cross section farm survey were filed by a program called Enable. This program consists of data base management, spread sheet, word processing, graphics and telecommunications. The data base management option was used to create a data base file. In addition, an input form was created. The input form consisted of questions in the questionnaire. The input form and data base file were joined by farm numbers of farmers interviewed. Data from the survey were entered on the input form and then stored in the data base management file.

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[25] For example, if extension workers conduct field demonstrations of new cultivars or fertilizer, they allow the host farmer to keep the extra inputs and products once the project is completed. In addition, some farmers associated interviews with loan approval.

The next step involved processing information stored in the data base file. Reports were designed to generate variables needed for statistical analysis. Because SAS (Statistical Analysis System) accepts only 80 columns, Enable spread sheet file was divided into two files. The two files were then transferred to the main frame computer and used for statistical analysis as a merged file.

5.3.1 Descriptive Statistics

Table 7 summarizes data by computing means and standard deviations of certain variables for the full sample, emergent and commercial farms. The full sample consists of 125 observations.[26] Based on the source of farm power, 77 observations were classified emergent farms. The sub sample for commercial farms consisted of 48 observations. The difference in number of observations between the two sub samples was designed to partially reflect dominance of emergent farms in maize production, i.e., in terms of number of farms and the proportion of maize produced.

As expected, the area of maize farms varies widely. Farm sizes ranged from as low as two acres to a high of 1250 acres. The full sample mean area of maize farms is 99.25 acres. This figure is influenced by large areas found on commercial farms. The average area of commercial maize farms is 242.73 acres. There is a very high variation in the

[26] Each district was divided into four areas. Then within each area, farmers were randomly interviewed. To minimize travel time, only farms within 30 kilometer radius were included in the sample. In addition, only farmers who sold maize were interviewed. Normally the sample size should be based on variance within the population. Since information on population variance was not available, the above approach was employed.

TABLE 7

Descriptive Statistics of the Survey

Criteria	Full Sample Mean	Full Sample Standard Deviation	Emergent Mean	Emergent Standard Deviation	Commercial Mean	Commercial Standard Deviation
Number of observations	125		77		48	
Land (acres)	99.25	233.35	9.81	9.32	242.73	330.74
Capital (K/farm)	11712.63	39649.37	415.46	539.45	29835.18	60021.83
Capital (K/acre)	99.77	315.22	40.31	45.91	195.15	493.63
Education (Av. # of years)	6.83	3.15	5.47	2.07	9.02	3.35
Labor (days/crop)	3233.14	4841.22	1273.86	648.54	6376.17	6691.56
Labor (days/acre)	150.79	148.20	209.07	157.10	57.28	59.51
Capital/unit of labor	1.63	3.43	0.36	0.45	3.68	4.87
Wage rate (K/day)	2.83	1.54	2.22	0.67	3.80	2.00
Other cash (K/acre)	134.66	107.88	89.30	49.32	207.44	134.13
Fertilizer (bags/acre)	4.27	2.23	3.58	1.38	5.39	2.82
Production (K/farm)	140034.40	366404.81	8800.00	9226.59	350556.25	529700.32
Production (K/acre)	1028.49	524.42	894.78	325.11	1242.99	691.65
Net revenue (K)	79134.62	211921.38	6456.02	7006.79	195723.21	309632.76
Net revenue/acre (K/acre)	697.67	433.14	662.54	315.31	754.03	573.55

farm sizes of commercial farms. For emergent farmers, the mean area of maize farms is 9.81 acres. These areas reflect differences in resource endowments.

One of the resources needed in production is non-land capital. The full sample average of non-land capital is K99.77 per acre. This value is strongly influenced by high levels of non-land capital (K195.15/acre) found on commercial farms. On the other hand, average emergent farm non-land capital is K40.31 per acre, thus it is relatively low. The value of non-land capital per farm reflects the amount of farm power available and plays an important part in determining the area of maize planted, thus emergent farms are generally smaller than commercial farms. This may be due to the fact that non-land capital is mostly made up of machinery and oxen.

In this study, education was measured by the average number of years of schooling per family. Evidence indicates that average number of years of schooling is greater on commercial farms (9.02 years) than on emergent farms (5.47 years). Because emergent farms tended to have more children, their average may have been affected by the younger ones with few years of schooling.

Labor is a major resource used by emergent farmers. On average, emergent farms use 209.07 adult equivalent days per acre. Commercial farms employ about 57.28 adult equivalent days per acre. This is because commercial farms depend on farm machinery to do most of the cultural practices. Therefore, capital-labor ratios (K/day) on emergent and commercial farms are 0.36 and 3.68, respectively. This implies that commercial farms are more capital intensive than emergent farms.

Hired labor is important on commercial farms. On average, commercial farmers use 29.63 days of hired labor per acre. Emergent farms employ 13.76 days of hired labor per acre. The amount of hired labor used depends on farm size, level of non-land capital, family size, and wage rates. Except for family size, all other resources are greater on commercial farms. The average wage rates on emergent and commercial farms are K2.22 and K3.80 per day, respectively. Therefore, commercial farms have a wage rate disadvantage with respect to hired labor. This is because they are required to follow government regulations dealing with minimum wage and benefits. Because of these, commercial farms try to offset costs by substituting machinery for labor and/or using temporary workers during peak periods. On the other hand, emergent farms are not affected by regulations and only use small quantities of hired labor.

The use of variable inputs falling under the other cash expenses category varies from group to group. On emergent farms, the average use of inputs purchased from other cash expenditures is low (K89.30/acre). Other cash expenditures on commercial farms is high (K207.44/acre). This is because commercial farms use large quantities of fuel, lubricants, herbicides and insecticides. The high levels of other cash expenses are needed to support the large quantities of non-land capital on commercial farms.

Fertilizer provides the nutrients needed for plant growth. Average fertilizer use on emergent farms is 3.58 bags (50 Kg bag) per acre. This level exceeds the recommended minimum number of 3.20 bags per acre, but falls short (18.63%) of the number of bags (4.4) needed to obtain high yields.[27] Commercial farmers, on average use 5.39 bags (50 Kg bags) per acre. This is (22.5%) greater than the maximum number recommended (4.4) for high yields. Up to a certain limit, yield increases with fertilizer. The smaller quantities of fertilizer used on emergent farms arises from insufficient cash outlays to make the necessary fertilizer purchases. As shown by the larger quantities of fertilizer on commercial farms, they do not have cash outlay problems on this input.

Production per acre, as represented by the value of output , varies between the two farm groups. Average production on emergent farms is K894.78 per acre. On average, commercial farms produce K1242.99 per acre. These production levels likely reflect resource endowments of the two farm groups. Despite the large quantities of non-land capital on commercial farms, production per acre is only 39 percent greater than emergent farms. Therefore, the increase in resources expands total production and only marginally affect output per acre. Unlike other variables, farmers found it easy to estimate the number of bags produced.

Net revenue was defined as revenue minus variable costs. When expressed per acre, net revenue of emergent farms (K662.54/acre) is lower than that of commercial farms (K754.03/acre). Therefore, commercial farm net revenue is only 14 percent higher than emergent farms. This implies that the extra resources influence total output rather than output per acre. These levels reflect quantities or values of fixed

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[27] If correct experimental data was used to determine the maximum recommended quantities of fertilizer, it would suggest that the marginal physical product is negative for quantities greater than 4.4 bags per acre. This study could not locate any information to suggest that the marginal physical product is negative. Because commercial farms marginally exceed the maximum quantity of fertilizer, it suggests that the point where the marginal physical product becomes negative is close.

resources which have not been accounted for. Because commercial farmers own higher levels of fixed resources, except for family labor, it is not surprising to find that commercial farmers have higher net revenues than emergent farmers.

5.3.2 Yield per Acre

The result of the interaction of production decisions, cultural practices, and environmental conditions is the quantity of maize produced. The yield per acre reflects the characteristics pertaining to each farm group.

Through trials on different sites (Jonsson [1977]), research has found that it is possible to obtain two (2) to 30 bags of maize per acre. He noted that exceptional farmers may exceed 30 bags per acre and that the lower end of the potential yield range is attained by some subsistence farmers. Table 8 shows the observed yield frequencies of the full sample, emergent and commercial farms.

TABLE 8

Distribution of Yield per Acre

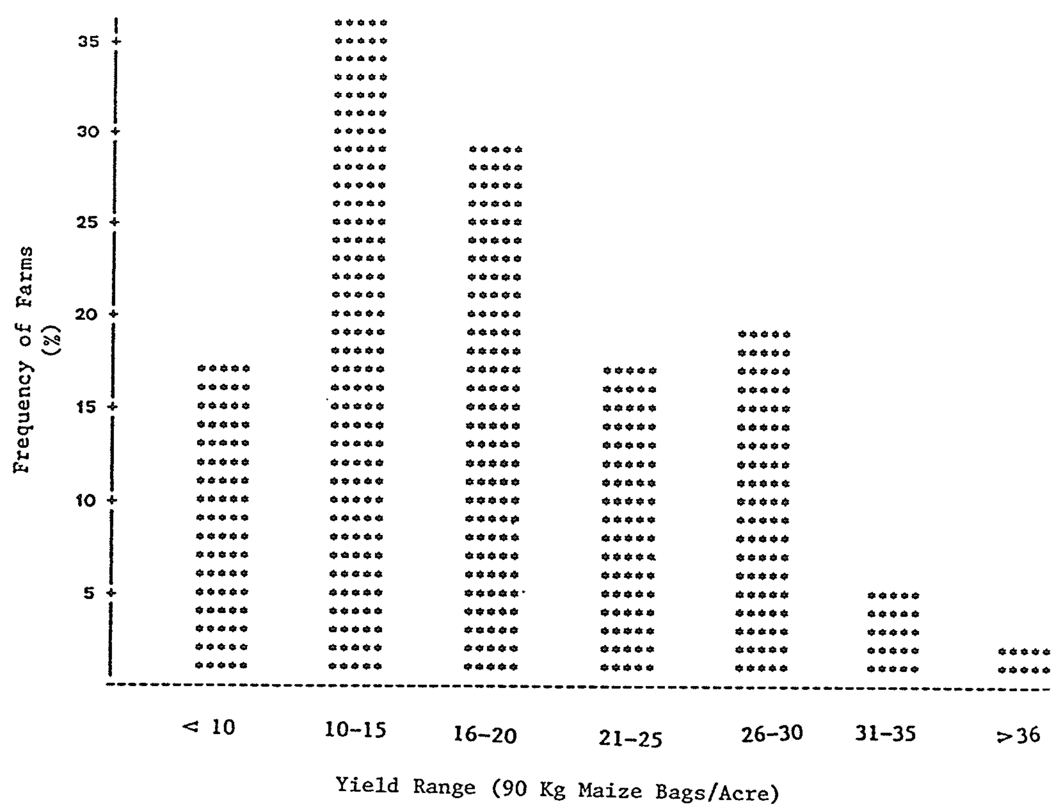
Yield/Acre (90 Kg bag)	Farm Groups					
	Full Sample		Emergent		Commercial	
	# of Farms	% of Farms	# of Farms	% of Farms	# of Farms	% of Farms
Less than 10	17	13.6	11	14.3	6	12.5
10 to 15	36	28.8	28	36.4	8	16.7
16 to 20	29	23.2	21	27.3	8	16.7
21 to 25	17	13.6	10	13.0	7	14.6
26 to 30	19	15.2	7	9.1	12	25.0
31 to 35	5	4.0	0	0.0	5	10.4
36 to 40	0	0.0	0	0.0	0	0.0
41 and over	2	1.6	0	0.0	2	4.2
Total	125	100.0	77	100.0	48	100.0
Average Yield per Acre	18.7		16.3		22.6	

According to the class ranges established, 14.3% of emergent and 12.5 % of commercial farms obtained less than 10 bags of maize per acre. Most (36.4%) emergent farms obtained between 10 and 15 bags of maize per acre. This compares with 16.7 percent of commercial farms which fell within this range. About half (50.7%) of emergent farms obtained 15 or less bags of maize per acre. On the other hand, about 29.2 percent of commercial farms obtained 15 or less bags per acre. Looking at the full sample, 42.4 percent of farms obtained less than half of the potential yield (15 bags per acre) of maize.

On further examination, 27.3 percent of emergent and 16.7 percent of commercial farmers obtained between 16 and 20 bags of maize per acre. This means that 65.6 percent of farms obtained two thirds (2/3) or less of the potential yield. The yield range of 21 to 25 bags per acre contains 13 percent of emergent and 14.6 percent of commercial farms. Between 26 and 30 bags per acre, there is 9.1 percent of emergent and 25 percent of the commercial farmers. Observed yields above 30 bags per acre are not common. Only 14.6 percent of commercial farms attained yields greater than 30 bags per acre. None of the emergent farms obtained yield levels greater than 30 bags per care.

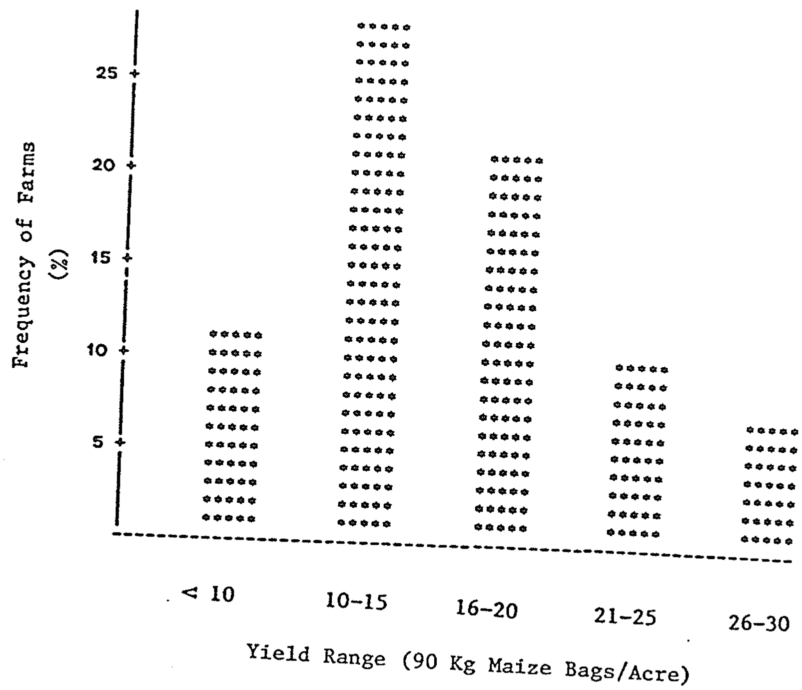
To study the distribution of yield, the results in Table 8 were presented in the form of bar diagrams. The length of bars are proportional to the class frequencies.

Figure 4: Full Sample Bar Diagram



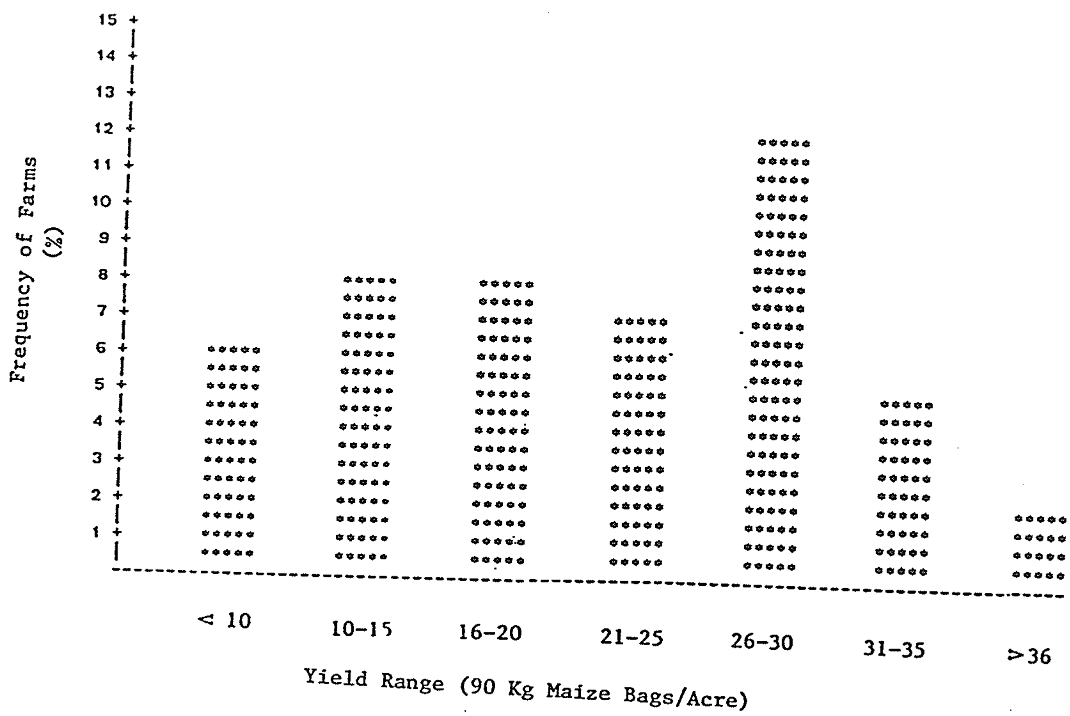
The full sample (Figure 4) is positively skewed because of the presence of some relatively high yields that are not offset by correspondingly low ones. Since these high yield values affect the mean, the mean of the full sample is skewed to the right. The median which measures the center of data and not affected by extreme values, is less than the mean yield of the full sample. Since most emergent farms had relatively low yield per acre, the mode is less than the median.

Figure 5: Emergent Farm Bar Diagram



Emergent farm yield distribution (Figure 5) is also positively skewed because of the dominance of relatively high yields per acre that are not offset by low ones. Because relatively high yields affect the mean, the mean is skewed to the right and the median is less than the mean. Because there are many emergent farms with relatively low yield per acre, the mode is less than the median.

Figure 6: Commercial Farm Bar Diagram



The distribution of commercial farm yield (Figure 6) is negatively skewed because of the presence of relatively low yields per acre. These shifted the average yield to the left. Because most commercial farms obtain relatively high yields per acre, the median and mode are to right of the mean.

This section indicates that 79.2 percent of farmers obtained 25 or less bags per acre. Only 15.2 percent of farmers obtained between 26 and 30 bags per acre. Few farmers (5.6%) obtained yields greater than 30 bags per acre. The conclusions to be drawn from these findings are:

1. Most emergent farms (90.9%) obtain less than the yield potential range (26 to 30 bags per acre).
2. About two thirds of commercial farms (60.5%) obtain less than the yield potential range (26 to 30 bags per acre).

These imply that either potential yields have been exaggerated or a lot has to be done to enable farmers to attain these levels. Because 39.5 percent of commercial farmers obtain 26 or more bags per acre, the yield potential has probably not been exaggerated. Since all farmers used hybrid seed, differences in cultural practices and other resource endowments could explain differences in yield. Results from the profit function may help in isolating some of the causes of yield differences.

5.3.3 Dependence on the Market

The profit function approach assumes that farmers sell most of their produce. This implies that farmers use the market. Dependence on the market is measured by the proportion of total sales. Table 9 shows the degree of dependence on the market of different sizes of farms.

The proportion of sales ranged from 63 to 100 percent. About 41 percent of farmers planted less than 10 acres of maize and on average sold 63 percent of maize harvested. The farm sizes between 10 and 20 acres contain 18.4 percent of farmers and sold 81 percent of total harvest.

Few farms (17.6%) exceed 100 acres. The majority of farms sell most of their produce (63% to 100%). This supports the assumption of a high degree of dependence on the market. Furthermore, most farm sizes (73.6%) are 50 acres or less. This indicates a predominance of small farm sizes.

TABLE 9

Dependence on the Market

Area Planted per Farm (acres)	Number of Farms	Proportion of Total Sales	Proportion of Maize Retained for Farm Use
Less than 10	51	0.63	0.37
10 - 20	23	0.81	0.19
21 - 30	7	0.81	0.19
31 - 40	6	0.87	0.13
41 - 50	5	0.84	0.16
51 - 60	6	0.95	0.05
61 - 70	1	0.80	0.20
71 - 90	1	0.90	0.10
81 - 90	1	1.00	0.00
91 - 100	2	0.85	0.15
Greater than 100	22	0.90	0.10

Except for family labor, commercial farmers use higher levels of production inputs than emergent farmers. The result is that commercial farms produce more per acre than emergent farms. Because some fixed inputs are measured in physical units (i.e., not valued), it is not possible to determine the net profit of each group. Therefore, descriptive information cannot be used to conclude that one group is more economic-efficient than another. The profit function approach will deal with this issue. However, information from this section describes the key features of maize production in Zambia.

Chapter VI

EMPIRICAL ESTIMATES

6.1 INTRODUCTION

This chapter presents parameter estimates for profit and input demand functions. Then, the results of hypotheses testing are presented. Later, the implications of hypotheses tested are discussed and then linked to the alternative policies to raise maize production in Zambia.

Parameter estimates were obtained through Zellner's method (seemingly unrelated regressions). A survey of Zambian farms provided data needed for estimation. It is important to note that each farm is unlikely to be using resources and producing crops in the most profitable way. However, input and output levels were assumed to be distributed about the equilibrium levels. Assuming that each farm represents movement towards the equilibrium level, then cross section data displays the long run equilibrium. This means that parameter estimates from cross section data represent long run equilibrium and deviations are due to errors.

The purpose of regression analysis is to explain movements in the dependent variable. Parameter estimates are then evaluated in terms of their conformity to the a priori economic expectations. Where possible an explanation is presented as to why the variable failed to display the expected sign.

6.2 ESTIMATED PARAMETERS AND STATISTICAL VALIDITY

Under seemingly unrelated regressions (Zellner's) method, the computer output consists of estimates from ordinary least squares (OLS) and joint generalized least squares (JGLS). Table 10 presents results from the two estimation methods.

The first task was to examine how well the estimated equation accounts for variation in the sample data. The goodness of fit is measured by the coefficient of determination (R^2). Using this measure, the profit function from the OLS has a higher R^2 (0.80) than the JGLS R^2 (0.74). This implies that the regression from the OLS method explains 80 percent of the variation in normalized profit, whereas the JGLS explains only 74 percent of the variation.

To confirm the findings from the R^2 test, OLS and JGLS F-ratios were used. The F-ratio tests the overall degree of fit of the equation. The observed OLS F-ratio (72.28) is greater than the critical F-ratio (2.09). This means that some of the explanatory variables influence profit. The observed JGLS F-ratio (124.47) is greater than the critical value (2.01). Therefore, the JGLS regression has variables that significantly influence profit. Because the OLS F-ratio is lower than JGLS, the study concludes that JGLS provides a better explanation of profit deviations from the mean.

However, R^2 and F-ratio tests are only necessary but not sufficient conditions. To examine the influence of included variables, estimated coefficients were tested to see if they are significantly different from zero. The t-statistic was used to test the null hypothesis that indi-

TABLE 10

Parameter Estimates of the Original Model

Variable Name		Parameter Symbol	OLS Estimate	Zellner's Estimate
PROFIT FUNCTION:				
Intercept		β_0	1.629 (1.758)*	0.654 (1.102)
Commercial farm dummy		β_1	-0.291 (-1.145)	-0.213 (-1.054)
Hired labor cost		β_2	-0.095 (-2.534)**	-0.027 (-1.129)
Fertilizer cost		β_3	0.560 (3.127)**	0.311 (2.735)**
Other cash expenditures		β_4	0.138 (0.906)	0.181 (1.865)*
Family Labor		β_5	-0.015 (-0.124)	0.185 (2.338)**
Non-land capital		β_6	0.039 (0.776)	0.060 (1.904)*
Area of Maize		β_7	0.407 (1.548)	0.461 (2.765)**
Education Proxy		β_8	-0.033 (-0.167)	-0.019 (-0.152)
INPUT DEMAND FUNCTIONS:				
Hired Labor-	Emergent	β_9	0.379 (1.507)	0.379 (1.507)
	Commercial	β_{10}	0.580 (1.852)*	0.580 (1.852)*
Fertilizer-	Emergent	β_{11}	0.474 (2.409)**	0.474 (2.409)**
	Commercial	β_{12}	0.482 (1.935)*	0.482 (1.935)*
Other cash-	Emergent	β_{13}	0.275 (2.076)*	0.275 (2.076)*
	Commercial	β_{14}	0.758 (4.516)**	0.758 (4.516)**
R^2			0.799	0.738

Figures in parenthesis are computed t values.
The critical t-values at
5 percent level of significance t = 1.645*
2 percent level of significance t = 2.326**

vidual parameters equal zero. In addition, the signs preceding estimated parameters were examined to see if they agree with a priori economic theory.

Most profit function parameters obtained through ordinary least squares are insignificant. Based on the t-statistic, only hired labor (β_2) is significant at 98 percent level of confidence. At this level of confidence, most OLS parameters in the input demand functions are not significant. In the commercial farm input demand functions, only other cash expenses (β_{14}) parameter is significant at 98 percent confidence level. For emergent farm input demand functions, the only significant parameter is fertilizer (β_{11}). When the significance level is lowered to 95 percent, then parameters: intercept(β_0), hired labor (β_2), fertilizer(β_3), commercial hired labor share (β_{10}), emergent fertilizer share (β_{11}), commercial fertilizer share (β_{12}), emergent other cash expenses share (β_{13}), and commercial other cash expenses share (β_{14}) are significant. If the significance level is further lowered (90 percent), two more parameters (maize area (β_7) and emergent hired labor share (β_9)) become significant, i.e., in addition to those which are significant at 95 percent confidence level.

Turning to parameter estimates from the joint generalized least squares (JGLS), some of the parameters which were statistically insignificant under OLS become significant. The JGLS profit function parameters β_5 (family labor) and β_7 (maize area) are significant at 98 percent confidence level. At this level, the JGLS input demand function parameters β_{11} (emergent fertilizer share), β_{13} (emergent other cash expenses share) and β_{14} (commercial other cash expenses share) are also significant. These are the same parameters which were significant in the OLS input demand functions. Note that the magnitudes of input demand function parameter estimates, from the OLS and the JGLS, are the same.

If the confidence level is lowered to 95 percent, the JGLS profit function parameters: fertilizer (β_3), other cash expenses (β_4), family labor (β_5), capital (β_6), and area harvested (β_7) are significant. Also significant are the JGLS input demand function parameters: commercial hired labor share (β_{10}), emergent fertilizer share (β_{11}), commercial fertilizer share (β_{12}), emergent other cash expenses share (β_{13}) and commercial other cash expenses share (β_{14}). By reducing the confidence level to 90 percent, all JGLS input demand function parameter estimates become significant. This was also true for parameter estimates of OLS input demand functions.

Therefore, by using a system method of estimation, there is an increase in the number of profit function parameters that are significantly different from zero. This means that they are relevant variables and should be included in the regression equation.

A further condition has to be satisfied before identifying a desirable estimation method for hypotheses testing. In Chapter 4, the a priori economic theory behind the model were discussed. In the following section, parameter estimates from the OLS and JGLS are examined to see if they conform to the expected signs.

6.2.1 Economic Interpretation of Estimated Parameters

In the OLS profit function regression, parameters β_1 (commercial dummy), β_2 (hired labor), β_5 (family labor) and β_8 (education), carry negative signs. The commercial farm dummy variable (β_1) may be negative if emergent farms have greater economic efficiency than commercial farms. If emergent farms are less economic-efficient than commercial farms, then β_1 may be positive. The hired labor coefficient (β_2) may be positive if the quantity effect is greater than the wage rate effect. Hired labor parameter is negative if the wage rate effect is greater than the quantity effect. Because the estimated parameter (β_2) is negative, the wage rate effect is greater than quantity effect. Even though farm wages are controlled by the government, they appear to vary from farm to farm. One reason is that it is difficult to implement government controls on a large number of farms. The positive coefficients on other variable inputs suggest that quantity effect dominates the price effect. The estimated OLS profit function parameters β_5 (family labor) and β_8 (education) possess negative signs. Being fixed parameters, they are expected to be positive because they assist in total yield expansion. The other OLS parameter estimates: hired labor (β_2), fertilizer (β_3), other cash inputs (β_4), capital (β_6), harvested area (β_7), hired labor shares (β_9 and β_{10}), fertilizer shares (β_{11} and β_{12}) and other cash input shares (β_{13} and β_{14}) have the expected signs.

The JGLS parameter estimates have the expected signs, except for education (β_8). A possible explanation for the wrong sign on β_8 is the method used to measure education per family. Since the average number of years of schooling per family is used, this study assumes that all members of the family take part in farm decisions. This may not be true in most farm households. However, the education proxy is insignificant at 90 percent confidence level. It implies that education, as measured in this study, may be an irrelevant variable. Therefore, it is excluded from the JGLS profit function. Probably the variable should have been measured by years of schooling of the farm operator. Pudasaini [1981] used this approach and found that education is positively related to profit.

Table 11 presents parameter estimates of the profit and input demand functions when the education proxy is excluded. There are no significant changes in parameter estimates. In addition, there is no change in the goodness of fit test (R^2). This further indicates that education, as measured, did not significantly contribute to the explanation of the variation in profit. With this modified model, all parameter estimates conform to the a priori economic theory. Except for β_0, β_1, β_2 and β_9, all parameter estimates are significant at 95 percent confidence level.

The most significant variables are fertilizer and harvested area of maize. This indicates the strong influence of these variables on profit. Their availability significantly affect profit. Availability of fertilizer and land are directly related to availability of equity and credit capital. Therefore, non-availability of capital could constrain profit and maize production. The least significant variable is hired labor. This shows that it has the least influence on profit. Because it does not significantly influence profit, hired labor may be in excess

TABLE 11

Parameter Estimates of the Modified Model

Variable Name		Parameter Symbol	Parameter Estimate	Computed t-Value
PROFIT FUNCTION:				
Intercept		β_0	0.610	1.227
Commercial farm dummy		β_1	-0.218	-1.094
Hired labor		β_2	-0.027	-1.135
Fertilizer		β_3	0.310	2.751**
Other cash expenditures		β_4	0.180	1.866*
Family labor		β_5	0.187	2.472**
Non-land capital		β_6	0.061	1.922*
Area of maize		β_7	0.460	2.772**
INPUT DEMAND FUNCTIONS:				
Hired labor	- Emergent	β_9	0.379	1.507
	Commercial	β_{10}	0.580	1.852*
Fertilizer	- Emergent	β_{11}	0.474	2.409**
	Commercial	β_{12}	0.482	1.935*
Other cash	_ Emergent	β_{13}	0.275	2.076*
	Commercial	β_{14}	0.758	4.516**
Goodness of fit		R^2	0.738	

Critical t-values at:
5 percent level of significance t = 1.645*
2 percent level of significance t = 2.326**

supply. The other possible explanation is that hired labor can be substituted (not perfect substitution) by non-land capital. The substitution is much more pronounced as farm size increases. When substitution is relatively easy, the marginal contribution to profit is lower than that of the substituting factor.

6.3 RESULTS OF HYPOTHESES TESTING

A number of hypotheses were developed in Chapter IV. Parameter estimates in Table 11 (p.120) were used to test these hypotheses. The focus is on hypotheses about individual and joint parameters. In this study, the F-statistic is used to test single and joint linear hypotheses. If the computed F-statistic is less than the critical F, then the null hypothesis cannot be rejected. On the other hand, the null hypothesis is rejected if the computed F-statistic exceeds the critical value.

6.3.1 Equal Economic Efficiency

Hypothesis number one tests for the equality of economic efficiency. This is tested through the null hypothesis that the estimated coefficient (β_1) for the commercial farm dummy variable in the profit function equals zero. Table 12 presents results of the test. At the 5 percent level of significance, computed F-value (1.234) is less than critical F-value (3.84). Therefore, at the 95 percent level of confidence, the null hypothesis of equal economic efficiency cannot be rejected. This means that commercial farms are as economic-efficient as emergent farms.

TABLE 12

Equal Economic Efficiency

Farm Group	Parameter Estimate	Null Hypothesis	Computed F-value
Profit function intercept (β_0)	0.610		
Profit function dummy (β_1)	-0.218	$\beta_1 = 0$	1.234
Commercial farm intercept if $D_2 = 1$	0.392		
Emergent farm intercept if $D_2 = 0$	0.610		

At the 5 percent level of significance and (1, 486) degrees of freedom, the critical F=3.84.

Since the commercial farm dummy coefficient (β_1) is negative, it indicates that emergent farms are more economic-efficient than commercial farms but the difference is not statistically significant. Therefore, the two farm groups are equally economic-efficient. By using the profit function intercept (β_0) and the dummy variable (β_1) estimate, commercial and emergent farm intercepts could be determined. These are also presented in Table 12. Recall that if the profit function dummy variable (D_2) is zero, then the profit function intercept is the emergent farm intercept. If the dummy variable (D_2) equals one, then commercial farm intercept is the sum of the profit function intercept and the value of β_1, i.e., $\{0.610 + (-0.218)\}$.

6.3.2 Relative Price Efficiencies of Variable Inputs

Economic efficiency is a function of price and technical efficiencies. For the two farm groups to be equally relative price-efficient, corresponding factor shares have to be equal. To examine the relative price efficiency of two farm groups, this study compared observed factor shares of every variable input. Table 13 presents the results of testing the null hypothesis of equal relative price efficiency with respect to hired labor.

TABLE 13

Equal Relative Price Efficiency of Hired Labor

Farm Group	Variable Input Symbol	Variable Input Estimate	Null Hypothesis	Computed F-value
Profit function	β_2	-0.027		
Emergent farms	β_9	0.379	$\beta_9 = \beta_{10}$	0.279
Commercial farms	β_{10}	0.590		

At the 5 percent level of significance and (1, 486) degrees of freedom, the critical value of F = 3.84.

At the 5 percent level of significance, computed F-value (0.279) is less than critical F-value (3.84). Therefore, at the 95 percent level of confidence, the null hypothesis of equal relative price efficiency for hired labor cannot be rejected. This means that emergent farms utilize hired labor as efficiently as commercial farms.

Emergent farms depend on family labor and use little or no hired labor. As farm size increases, commercial farms tend to depend more on farm machinery and less on hired labor. Evidence indicates that the two farm groups have equal relative price efficiency of hired labor. This means that the values of marginal products of hired labor are not significantly different among the two farm groups.

Fertilizer is needed to attain the potential yield of maize hybrids. To examine the degree to which each farm group efficiently utilizes fertilizer, the null hypothesis of equal relative price efficiency was tested. Table 14 shows the results of this test. At the 5 percent level of significance, the computed F-value (0.001) is less than the critical F-value (3.84). This means that at the 95 percent level of confidence, the null hypothesis of equal relative price efficiency of fertilizer cannot be rejected. Therefore, emergent farms employ fertilizer as efficiently as commercial farms. Note that parameter estimates for the two fertilizer demand functions are nearly the same. This implies that the two farm groups have roughly the same value of the marginal product of fertilizer. This indicates that emergent farms utilize fertilizer as efficiently as commercial farms.

TABLE 14

Equal Relative Price Efficiency of Fertilizer

Farm Group	Variable Input Symbol	Variable Input Estimate	Null Hypothesis	Computed F-value
Profit function	β_3	0.310		
Emergent farmers	β_{11}	0.474	$\beta_{11} = \beta_{12}$	0.001
Commercial farmers	β_{12}	0.482		

At the 5 percent level of significance and (1, 486) degrees of freedom, the critical value of F = 3.84.

The third variable input is other cash expenditures. To study how efficiently other cash variable inputs are utilized by the two farm groups, the null hypothesis of equal relative price efficiency was tested. The results of this test are presented in Table 15. At the 5 percent level of significance, the computed F-value (5.259) is greater than the critical F-value (3.84). Therefore, at the 95 percent level of confidence, the null hypothesis is rejected. However, at a 99 percent level of confidence, the test fails to reject the null hypothesis. The problem is that by raising the confidence level, the chances of committing type II error are increased, i.e., failing to reject a false hypothesis. To minimize this problem, the results at the 95 percent level of confidence are used. Therefore, there is a significant difference between the allocative efficiencies of emergent and commercial farms.

TABLE 15

Equal Relative Price Efficiency of Other Cash Expenditures

Farm Group	Variable Input Symbol	Variable Input Estimate	Null Hypothesis	Computed F-value
Profit function	β_4	0.180		
Emergent farmers	β_{13}	0.275	$\beta_{13} = \beta_{14}$	5.259
Commercial farmers	β_{14}	0.758		

At the 5 percent level of significance and (1, 486) degrees of freedom, the critical value of F = 3.84.

Most commercial farms use high levels of other cash inputs. The major components of other cash expenditures are herbicides and fuel. These are not used on emergent farms, thus their major component of other cash expenditures is hybrid seed purchase. Since the null hypothesis of equal relative price efficiency for other cash expenditures was rejected, the values of marginal products of commercial and emergent farms are different. This may be due to the difference in inputs used. Because other cash expenditures is an aggregate of several inputs, it may have created aggregation bias, thus affecting parameter estimates. In addition, most of the inputs in other cash expenditures are used according to manufacturer recommendations, thus the parameter estimate is derived from data with little variation. Because of little variation, the standard error is small and the computed t-value may be large, thus there is a tendency to reject the null hypothesis. Since this study employs an F-test, the relationship between F and t-statistics {i.e., $t = (F)^{.05}$} could be used to explain the influence of little variation on the rejection of the null hypothesis. Results indicate that the variable has a small standard error and high t-value.

For two farm groups to have equal relative price efficiency, they must simultaneously indicate that all variable inputs are efficiently utilized to the same degree. This is examined through the joint null hypothesis of equal relative price efficiency for all variable inputs. Table 16 presents the results of this test. At the 5 percent level of significance, the computed F-value (4.137) is greater than the critical F-value (2.60). Using the 95 percent level of confidence, the joint

TABLE 16

Joint Equal Relative Price Efficiency

Variable Input Name	Joint Null Hypothesis	Computed F-Value
Hired labor	$\beta_9 = \beta_{10}$	
Fertilizer	$\beta_{11} = \beta_{12}$	4.137
Other cash expenses	$\beta_{13} = \beta_{14}$	

At the 5 percent level of significance and (3, 486) degrees of freedom, critical F = 2.60.

hypothesis of equal relative price efficiency for all variable inputs is rejected. This is not surprising in view of the fact that the single hypothesis of equal relative price efficiency for other cash inputs was rejected.

6.3.3 Equal Technical and Relative Price Efficiencies

Failure to reject the joint null hypothesis of equal relative price efficiency implies that if economic efficiency is compared through the parameter estimate (β_1) of the profit function dummy variable, it is only a test for the equality of technical efficiency. To do this, the joint hypothesis of equal economic and relative price efficiencies is tested. Table 17 shows the results of this test. At the 5 percent level of significance, the computed F-value (3.112) is greater than the critical F-value (2.37). Therefore, the joint null hypothesis of equal technical and relative price efficiencies is rejected. This is to be expected because the joint hypothesis of equal relative price efficiency has already been rejected. This means that the technical efficiencies of the two farm groups are different. The problem is that the farm group with greater technical efficiency is not known. Before examining the technical efficiencies of emergent and commercial farms, the absolute efficiency theorem is used to identify the relatively more allocative-efficient farm group.

Profit maximization requires that the value of the marginal product (VMP) be equal to the factor price (marginal factor cost). Yotopoulos and Lau [1973] argued that absolute price efficiency is obtained when

TABLE 17

Joint Equal Technical and Relative Price Efficiency

Variable Name	Joint Null Hypothesis	Computed F-value
Profit function dummy	$\beta_1 = 0$	
Hired labor	$\beta_9 = \beta_{10}$	
Fertilizer	$\beta_{11} = \beta_{12}$	3.112
Other cash expenses	$\beta_{13} = \beta_{14}$	

At the 5 percent level of significance and (4, 486) degrees of freedom, the critical value is 2.37

the corresponding parameter estimates of variable inputs in the profit and input demand functions are equal. If this holds, then the farm group maximizes profit and equates the value of the marginal product (VMP) to the marginal factor cost. Table 18 presents the results of testing the null hypothesis of absolute price efficiency. Since the computed F-values are greater than critical values, the two farm groups are not absolute efficient. The high computed F-values suggest that data may have little variation.

It is difficult to test for the profit maximization condition if data consist of expenditures rather than prices of different inputs.[28] Therefore, not much weight is given to these results. In addition, farmers

[28] Garcia et al. [1982] argued that expenditure data is appropriate for testing relative efficiencies. In addition, this study assumed that farmers maximize profit, thus it is not necessary to test the assumption.

TABLE 18

Absolute Efficiency

Variable Name	Null Hypothesis	Computed F-value
Emergent:		
Hired labor	$\beta_9 = \beta_2$	
Fertilizer	$\beta_{11} = \beta_3$	107.965
Other cash	$\beta_{13} = \beta_4$	
Commercial:		
Hired labor	$\beta_{10} = \beta_2$	
Fertilizer	$\beta_{12} = \beta_3$	256.890
Other cash	$\beta_{14} = \beta_4$	

At the 5 percent significance level and (3, 486) degrees of freedom, the critical F = 2.60.

may consider other factors, e.g., risk and uncertainty, when pursuing the profit maximization objective. For commercial farmers, access to subsidized inputs may also encourage less than efficient management. Because emergent farms (on average) use less than recommended quantities of inputs per acre, this may explain why they are not absolutely price-efficient.

Because the joint null hypothesis of absolute price efficiency was rejected, this study used another criteria (based on absolute price efficiency) to infer the farm group with greater relative price efficiency. Following O'Connor and Hammonds [1975], a ranking technique was employed. The ranking is based on the hypothesis that absolute price efficiency occurs when parameter estimates of variable inputs in the profit and input demand function are equal. If farm groups are not absolute price-efficient, then the group with the least deviations of the corresponding parameter estimates, of the profit and input demand functions, is relatively more efficient. Table 19 provides a ranking of parameter estimates of input demand functions.

TABLE 19

Relative Price Efficiency Ranking

Source of Parameter Estimate	Ranking of Corresponding Variable Input Parameters		
	β_2	β_3	β_4
Profit function parameter estimates	-0.027	0.310	0.180
Input demand functions for:			
Emergent farms	0.379	0.474	0.275
Commercial farms	0.580	0.482	0.758

Farm groups are ranked from the most to the least relative efficient. For all three variable inputs, emergent farms have the least deviations from the corresponding profit function parameters. Therefore, emergent farms are relatively more price-efficient than commercial farms. This result may be explained by the fact that emergent farmers own small quantities of resources. Because emergent farmers retain a portion of the produce for family consumption, they associate survival with maize production, thus it is given maximum attention. In addition, emergent farmers plant small areas, thus they pay closer attention to the utilization of resources than commercial farmers who look after large areas. Another reason is that commercial farmer access to subsidized inputs may have encouraged inefficient allocation of resources. If emergent farms are more relative price-efficient and the two farm groups have the same economic efficiency, it is possible to identify the group with greater technical efficiency.

Technical efficiency is output per unit of inputs. A joint test for equal relative economic and price efficiencies is a test for technical efficiency. Since this test was rejected, the two farm groups have different technical efficiencies. To infer the farm group with greater technical efficiency, the relationship between economic, price and technical efficiencies was used. Economic efficiency is defined as follows (Farrell [1957], Seitz [1970], Hall and LeVeen [1978], Kilmer and Armbruster [1984]):[29]

$$EE = (TE)(PE)$$

Where

EE = economic efficiency

TE = technical efficiency

PE = price efficiency

[29] The relationship of economic efficiency is multiplicative because the production function behind the profit function is multiplicative.

An increase in technical and/or price efficiencies would increase the economic efficiency of production. Therefore, technical efficiency is the ratio of economic and price efficiencies.

$$TE = EE/PE$$

Because the ranking technique indicated that emergent farms are relatively more price-efficient, and the economic efficiency test found no significant difference between the two farm groups, then the technical efficiency of commercial farms is greater than emergent farms.

$$\text{Technical efficiency} = \underbrace{\frac{\text{Economic efficiency}}{\text{Price efficiency}}}_{\text{Commercial}} > \underbrace{\frac{\text{Economic efficiency}}{\text{Price efficiency}}}_{\text{Emergent}}$$

Where

$>$ = greater than

This holds only if the price efficiency of emergent farms is greater than that of commercial farms and the two farm groups have equal economic efficiency.

6.3.4 Testing for Economies of Scale

To examine the output implications of proportionately increasing all inputs, this study examined the concept of economies of scale. The null hypothesis consists of a linear combination of the coefficients of family labor, non-land capital and harvested area of maize. To establish the existence of constant returns to scale, the sum of the three coefficients should not be significantly different from one.[30] The appropriate test is the F-statistic. Table 20 shows the results of testing for the existence of economies of scale.[31] At the 5 percent level of significance, the computed F-statistic (3.085) is less than the critical F-value (3.84). Therefore, at the 95 percent level of confidence, the test fails to reject the null hypothesis, thus the two farm groups operate under constant returns to scale. This means that if all inputs were increased by the same proportion, then output would increase by the same proportion.

TABLE 20

Constant Returns to Scale Test

Variable Name	Parameter Symbol	Parameter Estimate	Null Hypothesis	Computed F-Value
Family labor	β_5	0.187		
Non-land capital	β_6	0.061	$\beta_5+\beta_6+\beta_7=1$	3.085
Acres harvested	β_7	0.460		

At the 5 percent level of significance and (1, 486) degrees of freedom, critical F = 3.84.

[30] If the sum of fixed input coefficients is significantly greater than one, then increasing returns to scale exist. If the sum is less than one, then decreasing returns to scale exist.

[31] The study jointly tests for constant returns to scale because the profit function approach accounts for differences in the quantities of inputs used, thus the same results would be obtained if the two farm groups were tested separately.

6.4 SUMMARY OF THE RESULTS OF TESTED HYPOTHESES

If critical values are determined at the 5 percent significance level, then the following results are obtained:

1. Emergent and commercial farmers have equal relative economic efficiency.
2. Emergent and commercial farmers have equal relative price efficiency for hired labor and fertilizer. However, they do not have equal relative price efficiency with respect to other cash inputs.
3. A joint test for equal economic and price efficiencies was rejected, thus indicating that the two farm groups have different technical efficiencies.
4. Based on the ranking technique, it appears that emergent farmers are relatively more allocative-efficient than commercial farmers.
5. Using the economic efficiency identity, it is possible to conclude that commercial farmers are more technical efficient than emergent farmers.
6. Both commercial and emergent farmers operate under constant returns to scale.

Chapter VI presented parameter estimates and the results of testing different hypotheses. Chapter VII examines the policy implications of parameter estimates and results from the tested hypotheses.

Chapter VII

ANALYSIS OF RESULTS

7.1 ANALYSIS OF ELASTICITIES

7.1.1 Introduction

Maize is the staple food of Zambia, thus most people are convinced that raising maize production is a desirable objective of public policy. This in itself is sufficient reason to examine the adequacy of some alternative policies to raise maize production. Many policy makers believe that policies they inact could increase maize supply. However, it is not known by how much. This information is necessary in setting production incentives and planning for imports of inputs and maize.

Elasticity measures the degree to which a function responds to a change in one of the factors that influence it. Using elasticity estimates, it is possible to predict implications for factor use, output supply and returns to fixed factors. Therefore, the objective of this section is to estimate elasticities of input demand and maize supply functions. Lau[1971] and Yotopoulos [1976] argued that profit function elasticities are appropriate for assessing the response of output supply and profit to alternative policies for they measure total (direct and indirect effects) rather than partial influence. For the profit function, elasticity is given by the percentage change in profit relative to the percentage change of one of the profit determinants, when other variables are constant, i.e., E = %Change in Profit/%Change in Input

Where

E = elasticity

Therefore, it is a ratio with no units.

In this study, profit is a function of variable input expenditures and quantities of fixed inputs. The associated input demand functions indicate profit maximizing amounts of variable factors. The four equations (#s 17 to 20, p.77) were jointly estimated to obtain parameter estimates in Table 11 (p.120). These parameters are used to specify the following equations:

Profit function

$$NR = 0.610 - 0.218D_2 - 0.027HL + 0.310F + 0.0180CE + 0.187FL + 0.061K + 0.460A \quad \ldots(21)$$

Input demand functions[32]

$$HL/NR = -0.379D_1 - 0.590D_2 \quad \ldots(22)$$

$$F/NR = -0.474D_1 - 0.482D_2 \quad \ldots(23)$$

$$CE/NR = -0.275D_1 - 0.758D_2 \quad \ldots(24)$$

Where

NR = net revenue

D_2 = commercial farm dummy variable (D_2 = 1 if commercial, 0 if not)

D_1 = emergent farm dummy variable (D_1 = 1 if emergent, 0 if not)

HL = hired labor expenditure

[32] The dependent variables of input demand functions (equation #s 18 to 20, p.77) are negative. To make dependent variables positive, each equation is multiplied by minus one (-1).

F = fertilizer expenditure (K)

CE = other cash expenditures (K)

FL = family labor (adult equivalent days)

K = non-land capital (K)

A = area harvested

HL/NR = hired labor-net revenue ratio

F/NR = fertilizer-net revenue ratio

CE/NR = other cash expenses-net revenue ratio

7.1.2 Own and Cross Price Elasticities

Variables on the left hand side of equations (#s 1 to 4 in section 7.1.1) are dependent variables and those on the right are independent variables. Independent variables reflect some of the policy instruments available to policy makers.[33] Before enacting any policy, decision makers want to know the maize output response to alternative policies.

Elasticity estimates measure the influence of alternative policies. Using parameter estimates in the four equations (#s 21 to 24, p.137) and elasticity relationships in Appendix C (p.198), it is possible to derive variable input demand and maize supply elasticities, with respect to change in variable input price and quantities of fixed factors of production. The values of variable input elasticities are presented in Table 21.[34] For purposes of interpretation, elasticities are better

[33] In the short run, policy instruments are hired labor, fertilizer and other cash expenses. In the long run, policy instruments expand to include family labor, non-land capital and harvested area.

[34] The elasticities on each row are similar because an increase in the use of one variable alters the optimal conditions and thus other variables adjust to restore optimality. The change in other variables is determined by the parameter estimate of the variable which

TABLE 21

Variable Input Own and Cross Price Elasticities

Variable Changed	Variable Response			
	Hired Labor	Fertilizer	Other Cash Expenses	Maize Supply
Hired Labor	1.027	0.027	0.027	0.027
Fertilizer	0.310	1.310	0.310	0.310
Other Cash Expenses	0.180	0.180	1.180	0.180

expressed in absolute values.

Each column indicates percentage change of the quantity of the variable input per one percent change of the price of the variable on each row. Thus by varying the marginal factor cost of a variable input, it is possible to determine the change in the quantity demanded of the variable input.

Own elasticity measures the direct impact on the quantity of the variable input demanded per unit change of the variable input price. The own elasticity estimates for hired labor, fertilizer and other cash expenses are 1.027, 1.310 and 1.180, respectively. Because own elasticity estimates are greater than one, they indicate elastic response. According to own elasticity estimates in Table 21, hired labor is the least elastic while fertilizer is the most elastic. These direct changes in quantities of inputs affect maize output.

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induced the adjustment. See Appendix C, (p.199 to 201).

The productivity of a given input is not independent of the level of other inputs used in production. The cross price elasticity of a variable input indicates the change in the quantity demanded of a given input per unit change of the price of another input. Therefore, cross elasticity measures the indirect impact of a change in a given factor on the use of other factors. The computed cross elasticities in Table 21 are less than one (1), i.e., they are inelastic. The change in the quantity of other factors in turn affect the output. These results indicate that cross elasticities are the parameter estimates of the changing variable.

Maize output is a function of inputs. Because the quantities of variable inputs demanded change as prices change, maize output also changes. To measure maize supply response to variable input price change, elasticity estimates are derived (Table 21). These indicate that maize supply is inelastic to variable input price changes.

The wage effect of hired labor is greater than the quantity effect, thus the hired labor parameter estimate (β_2) is negative. A 10 percent decrease in the wage rate would increase quantity of labor demanded by 10.27 percent (Table 21). This would alter optimal conditions, thus other factors adjust to restore optimality. The magnitude of these secondary adjustments is measured by cross elasticities. Cross elasticities indicate that a 10 percent decrease in the wage rate would increase the quantities of fertilizer and other cash inputs by 0.27 percent. Since a wage rate decrease increases the quantity demanded of hired labor, fertilizer and other cash inputs, it also changes maize supply. Table 21 indicates that if hired labor wage rate decreased by 10 percent, it would increase maize supply by 0.27 percent.

An increase in the wage rate would decrease profit and maize production. This implies that government actions designed to enforce higher wage rates in the maize industry would not be helpful in raising maize production. On the other hand, a 10 percent decrease in the wage rate would increase profit by 0.27 percent. Since the farmer's objective is profit maximization, maize production would also expand by 0.27 percent. Therefore, a 10.27 percent increase of hired labor would increase the quantity of maize supply by 0.27 percent. This implies that a decrease in the wage rate would contribute to increased maize production and employment. If wage rates decrease by 10 percent, the net incomes of farm workers would be 10 percent lower than current incomes. It is possible that some people could withdraw their labor because of reduced incomes. However, limited job opportunities in other sectors of the economy would ensure adequate supply of labor. Therefore, policy makers have to weigh the loss in net income against the gain in employment.

In Zambia, all farmers pay the same price per bag of fertilizer. However, different farms employ different quantities of fertilizer. Thus, differences in fertilizer expenditure is due to the quantity of fertilizer used. Up to a certain level, an increase in fertilizer increases total yield and revenue. Therefore, the parameter estimate for fertilizer (β_3) is positive. If the price of fertilizer dominates the quantity effect, β_3 would be negative. Table 21 indicates that a 10 percent decrease in the price of fertilizer would increase the quantity demanded of fertilizer by 13.10 percent. The cross price elasticities indicate that quantity demanded of hired labor and other cash inputs would expand by 3.10 percent. The result is that maize supply and profit would increase by 3.10 percent. Because most commercial farms use more fertilizer than recommended quantities per acre, additional quantities may be most useful to emergent farms.

The quantity effect of other cash inputs is greater than the price effect, thus the parameter estimate β_4 is positive. A price decrease increases the quantity demanded of the inputs in this class. A 10 percent decrease in the price of other cash inputs would increase the quantity demanded by 11.80 percent (Table 21). The cross price elasticities of other cash inputs indicate that the quantity demanded of hired labor and fertilizer would each increase by 1.8 percent. These variable input changes would increase maize supply by 1.8 percent. On the other hand, a 10 percent increase in the price of other cash inputs would decrease production and profit by 1.8 percent.

For commercial farmers, other cash inputs is an aggregate of several inputs, thus it is difficult to know the individual influence. However, other cash expenses for emergent farmers consist of seed maize, thus it is easy to assess the influence of a price change.

7.1.3 Fixed Input Elasticities

In the long run, quantities of fixed factors may be changed. The elasticities of fixed inputs measure the influence of a specified change in the fixed factor. Lau and Yotopoulos [1972] argued that an increase in a fixed factor shifts the marginal product curves of all variable inputs. Since the prices of output and inputs are constant, a change in the quantity of the fixed input shifts the marginal productivity curves of all inputs. To maintain optimality, more inputs are employed. In the long run all inputs are variable, thus the cross price elasticities of short run variable inputs come from parameter estimates of family labor, non-land capital and harvested area (Table 22). The cross elasticities of the quantity demanded of variable inputs with respect to family labor, non-land capital and harvested area are 0.187, 0.061 and 0.46, respectively. These elasticities indicate that they are inelastic. Because variable inputs are allowed to adjust, the impact is greater than would be the case.

TABLE 22

Fixed Input Elasticities

Variable Changed	Variable Response			
	Hired Labor	Fertilizer	Other Cash Inputs	Maize Supply
Family labor	0.187	0.187	0.187	0.187
Non-land capital	0.061	0.061	0.061	0.061
Harvested area	0.460	0.460	0.460	0.460

If family labor is increased by 10 percent, the quantities demanded of hired labor, fertilizer and other cash inputs would each increase by 1.87 percent. Because the quantities of variable inputs increase, the quantity of maize supplied would increase by 1.87 percent per 10 increase of family labor. Natural limitations to expansion of family labor would make this interpretation unrealistic.

Non-land capital has the least fixed input elasticity. Many commercial farms own large quantities of non-land capital, thus the low elasticity may indicate some degree of under utilization. Where multiple enterprises existed, it was difficult to impute service flow to each enterprise. If service flow was wrongly imputed to maize, it may not reflect the full productivity. Table 22 indicates that a 10 percent change in non-land capital would increase quantity demanded of each variable input by 0.61 percent. This would raise the quantity of maize supply by 0.61 percent.

Maize area has the highest fixed input elasticity. A 10 percent change in maize area would increase the quantity demanded of each variable input by 4.60 percent. This would increase the quantity of maize supply by 4.60 percent. Even though harvested area has the most significant response, non-land capital constraints could make this policy less responsive.

7.1.4 Summary of Elasticity Analysis

In reality several variables may change at the same time. To measure overall influence, cross and own elasticities of variables are aggregated. For example, a change in the quantities of fertilizer could also expand the quantities of other variable inputs. To determine the influence of a variable change on maize supply, individual elasticities have to be aggregated.

In the short run, fertilizer has the highest maize supply response (0.310). Other cash expenses has the next highest maize supply response (0.180). Hired labor has the least response (0.027). This indicates that hired labor has a low marginal physical product. Therefore, this suggests that hired labor may be in excess supply. Because agriculture has also been called upon to create jobs, it implies that attempts to enforce minimum wages higher than current wages may reduce maize supply, profit and farm employment. In addition, high minimum wages could encourage substitution of machinery for hired labor.

Therefore, it appears that raising maize production will depend on the rate at which fertilizer use increases. As fertilizer use is increased by 10 percent, the quantities demanded of hired labor and other cash expenses would each expand by 3.10 percent. Because more hired labor and other cash expenses are employed, maize supply may expand by 3.74 percent {i.e., 3.10 + 3.10(0.027) + 3.10(0.180)}. Beyond a certain limit, fertilizer is toxic to the maize plant. Because commercial farms already apply large quantities of fertilizer, this result may be more applicable to small farms.

In the long run, harvested area expansion has the biggest influence on maize supply. This policy option is constrained by the need to substitute machinery for labor as farm size increases, especially under the current foreign exchange problems the country is facing. Family labor is the next most important input in raising maize supply. This alternative is important in view of the prevalence of small farms and their dependence on family labor. Family labor cannot be changed easily because of the existence of the natural limit (ability to bear and raise children to maturity) to family size expansion. Non-land capital has the least influence. Capital as measured, in this study, may not reflect its total productive value. Because many farms produced several crops, the allocation of non-land capital may have been faulty. The existence of constraints to family labor, non-land capital and harvested area expansion implies that increased maize production has to come from intensive use of existing areas.

An increase in the quantity of purchased inputs could arise from a price decrease or an increase in the farmer's budget. Usually prices do not decrease and the quantity increase arises from an increase in the farm budget. Input budget consist of equity and credit capital. Most farmers do not have the extra cash to meet the additional input costs. Therefore, an increase in the supply of and access to credit would facilitate the purchase of additional inputs. Low capital-land ratios on emergent farms indicate that the capital constraint is critical. In addition, the history of the maize industry indicates that most emergent farmers have limited access to borrowing. This is related to the lack of collateral to secure a loan. This suggests that there is need to examine ways of increasing the supply of loanable funds and to eliminate constraints which prevent emergent farms from having access to credit. Any attempts to raise maize production would lead to increased demand for foreign exchange to finance imported inputs. Intensive use of existing areas could lead to the least demands on imported inputs. In addition, expansion of the fertilizer plant in Zambia could further reduce the demands on foreign exchange.

This study assumed that the influence of excluded variables is insignificant. However, extension services could assist farmers in following proper practices. The next section examines the policy implications of observed economic, price and technical efficiencies.

7.2 IMPLICATIONS OF OBSERVED EFFICIENCIES

Maize production may be increased through better use of existing resources, applying more variable inputs and adoption of more productive technologies. These actions increase the economic efficiency of maize production. Before embarking on any policy to encourage one farm group to increase maize production, there is need to determine the farm group with greater economic efficiency. A farm is more economic-efficient if it minimizes cost or maximizes profit per unit of output.

Chapter VI empirically examined the economic efficiencies of emergent and commercial farms. This section analyzes the results of testing different hypotheses. The objective is to identify the farm group with better input use and to indicate the economic efficiency loss or gain resulting from encouraging one farm group to raise maize production.

The results of hypotheses tested in Chapter VI are summarized in Table 23. These results were obtained at the five percent level of significance and are the basis of the analysis in this section.

TABLE 23

Summary of Hypotheses Tested Based on the F-Statistic

Hypotheses	Null Hypothesis	Degrees of Freedom	Computed F-value
Equal economic efficiency	$\beta_1 = 0$	(1, 486)	1.234
Equal allocative efficiency for:			
Hired labor	$\beta_9 = \beta_{10}$	(1, 486)	0.279
Fertilizer	$\beta_{11} = \beta_{12}$	(1, 486)	0.001
Other cash expenses	$\beta_{13} = \beta_{14}$	(1, 486)	5.259
Joint equal price efficiency	$\beta_9 = \beta_{10}$ $\beta_{11} = \beta_{12}$ $\beta_{13} = \beta_{14}$	(3, 486)	4.138
Equal technical efficiency	$\beta_1 = 0$ $\beta_9 = \beta_{10}$ $\beta_{11} = \beta_{12}$ $\beta_{13} = \beta_{14}$	(4, 486)	3.112
Constant returns to scale	$\beta_5+\beta_6+\beta_7=1$	(1, 486)	3.085

Note: β_1 = parameter estimate for commercial farm dummy (D_2)
β_9 = emergent farm hired labor share
β_{10} = commercial farm hired labor share
β_{11} = emergent farm fertilizer share
β_{12} = commercial farm fertilizer share
β_{13} = emergent farm other cash expenses share
β_{14} = commercial farm other cash expenses share

At the 5 percent significance level and the following degrees of freedom critical F-values are:

$F_{(1,486)} = 3.84$
$F_{(3,486)} = 2.60$
$F_{(4,486)} = 2.37$

7.2.1 Economic Efficiency

If farmers maximize profit, then more economic-efficient farms make greater profit than others. A farm is economic-efficient if it minimizes costs of production. Using the profit function, the difference in the economic efficiency of the two farm groups was measured through the profit function dummy parameter (β_1). This study found that emergent farms are marginally more economic-efficient than commercial farms by about 22 percent (22%), i.e., emergent farms have marginal profit advantage. However, this difference is not statistically significant. Therefore, profit is virtually the same over a wide range of farm sizes. It means that under current conditions, emergent farms are as economic-efficient as commercial farms. Similar studies (Sidhu and Baanante [1979], Hall and LeVeen [1978], and Garcia et al. [1982]) have reached the same conclusion.

If economic efficiency is the major consideration, then there is no need for policy to encourage one farm group over another. Therefore, increased maize production could come from the two farm groups. Most arguments (World Bank [1975], and EEC [1980]) for broad based maize production focus on equity rather than economic efficiency. This study indicates that there is no conflict between economic efficiency and equity arguments to increase maize production. If equity considerations are important, resource allocation could be biased towards emergent farmers without loss in economic efficiency. This would just be an income transfer.

The World Bank [1984a] concluded that in terms of domestic resource use, emergent farmers are more efficient producers of maize than commercial farmers. Because Zambia has insufficient foreign exchange to finance imports (e.g., machinery and oil), emergent farmers ought to be encouraged to produce more maize. Since this study indicates that emergent farmers are as economic-efficient as commercial farmers, increasing maize production through emergent farmers cannot lead to economic efficiency loss. Therefore, the findings of this study reenforce the World Bank conclusion.

7.2.2 Allocative and Technical Efficiencies

Economic efficiency is a function of price (allocative) and technical efficiencies. By examining these components it is possible to explain the observed economic efficiency. To study the relative price efficiency of the two farm groups, the variable input factor shares were compared. Absolute efficiency occurs when profit is maximized. This is attained when the value of marginal products of variable inputs in the profit and input demand functions are equal. This study rejected absolute efficiency for the two farm groups. This means that inputs are not earning their opportunity cost. To encourage farmers to maximize profit, it may be necessary to offer input and output prices which reflect opportunity cost, reduce risk, and increase emergent farm access to additional inputs. Risk may be reduced through timely availability of inputs and early announcement of producer prices. In addition, improved extension and information services could help raise the allocative efficiency.

Since absolute efficiency was rejected, the study examined the relative allocative efficiency of the two farm groups. Results indicate that the two farm groups are equally relative price-efficient with respect to hired labor and fertilizer. This means that the values of marginal products are not significantly different. If true, then reports {EEC [1980], World Bank [1984b]} of emergent farms spreading their resources too thin may be unfounded. The ranking technique found emergent farms to be more relative allocative-efficient. Shultz [1964] and Collinson [1983] argued that there are insignificant inefficiencies in the allocation of resources in the traditional agriculture. This study agrees with the conclusion in as far as the relative allocative efficiency is concerned. Therefore, any attempts to improve the management ability of emergent farmers may be an ineffective way of raising maize production. On the other hand, commercial farmers may gain more than emergent farmers from programs designed to improve allocative efficiency. This implies that trained extension workers are needed to show commercial farmers how to better utilize the available resources. Since emergent farms have greater price efficiency than commercial farms, their marginal return to additional resoures is higher. Therefore, additional resources ought to be directed at emergent farms.

A test for joint equal relative economic and price efficiencies was rejected because the two farm groups have different factor shares for other cash inputs. This implies that emergent and commercial farms have different technical efficiencies, thus output per unit of inputs may be greater on commercial farms. Commercial farms may be more technical-efficient because of easier access to inputs. This has enabled commercial farms to utilize the full production potential of the maize hybrids. It implies that increased access to inputs could increase the output per unit of inputs of emergent farmers. Shultz [1964] suggested that policy and institutions could make this opportunity available.

7.2.3 Constant Returns to Scale

This study found that the two farm groups operate under constant returns to scale. This means that the change in output is equal to a proportionate change in all inputs. This concept has problems in agricultural applications because input proportions from different optimal combinations vary with the level of output. In addition, some inputs (e.g., tractors) increase in discrete amounts only, thus proportional increase in all inputs is difficult to achieve. However, it is useful to examine this concept for it indicates that efficient farms could exist in a wide range of sizes, and thus supports the equal economic efficiency conclusion. This means that both farm groups could be encouraged to produce maize. If equity and domestic resource use criteria are employed as the basis for decision, constant returns to scale indicates that allocating more resources to emergent farmers cannot lead to a loss in maize output. Since commercial farms, on average, use input quantities greater than recommended, a policy designed to transfer some of the inputs to emergent farms cannot reduce overall production.

7.2.4 Summary of Economic Efficiency Implications

This study indicates that emergent farms are as economic-efficient as commercial farms. It also indicates that emergent farms more nearly maximize profit than commercial farms, i.e., more relative allocative-efficient. However, commercial farms are more technical-efficient. In addition, the two farm groups operate under constant returns to scale. This indicates that efficient farms could exist in a wide range of sizes.

Economic efficiency requires that resources be directed at the farm group with greater relative economic efficiency. Since emergent and commercial farms have equal relative economic efficiency, both groups ought to be encouraged to increase maize production. Therefore, the results indicate that large farm sizes do not result in economic efficiency gains. This suggests that focusing on large farm size only results in additional income for the farmer. Because most of the purchased inputs are subsidized, with a view to helping small scale farms, and commercial farms use a big proportion of those inputs, it may be a mis-allocation of the resources. It is possible that the past dominance of commercial farms may have been influenced by marketing costs, credit constraints and technology than short run productive efficiency.

Chapter VIII

SUMMARY, CONCLUSIONS AND SUGGESTIONS

8.1 SUMMARY

A large percentage of the population in Zambia depends on maize for food, income and employment. This study jointly estimated the profit and variable input demand functions, using 1985/86 cross section farm data. The results were then used to compare economic, technical and allocative efficiencies of emergent and commercial farmers. The findings were used to comment on alternative policies to promote maize production.

If farmers maximize profit, then increasing profit would lead to increased maize production. Any other actions to de-control maize prices and exchange rate adjustment may contribute to increased profits. This could occur through increased revenues and the timely availability of imported inputs. Other policies that raise production directly or indirectly would help improve profits of maize producers, if costs of production and price of maize do not change proportionally. Under prevailing production conditions, the results indicate that profit increases as fertilizer and other cash inputs increase. Profit decreases as the wage rate for hired labor increases and increases with all fixed factors, except for the education proxy which failed to display its expected influence. Most of the parameters of input demand functions were significant.

Despite the high level of capital found on commercial farms, there is no significant difference in the economic efficiency of the two farm groups. This means that the two farm groups maximize profit or minimize costs to the same degree. Therefore, commercial farms may be just duplicating the optimum input levels to many acres. Economic efficiency requires that limited resources be directed at the farm group with the most favourable return per unit of inputs, thus the two farm groups should be encouraged to increase maize production. The two farm groups were equally relative price-efficient with respect to hired labor and fertilizer. However, commercial and emergent farms are not equally relative allocative-efficient with respect to other cash inputs. A joint test for equal economic and relative price efficiencies was rejected, thus the two farm groups do not have the same technical efficiency. Using the ranking technique, it is possible to conclude that commercial farms are less relative allocative-efficient than emergent farms. If this result and the economic efficiency definition are used, it is possible to infer that commercial farms are more technical-efficient. Finally, evidence indicates that the two farm groups are not absolute-efficient and operate under constant returns to scale.

Most policy recommendations are based upon a belief that emergent farmers are less economically efficient, e.g., the World Bank [1986] program to improve emergent farm extension services. The main arguments put forward rely upon the existence of deficiencies in emergent farm management and technical efficiency. The results of this study indicate that because the two farm groups have equal economic efficiency, there is a possibility of focusing on the wrong constraints. Results from the ranking technique indicate that emergent farms are more allocative-efficient than commercial farms. This means that policies designed to improve the management of emergent farmers may be ineffective. Because commercial farms are less allocative-efficient, they may be targeted for management improvement.

Improving extension services is needed but not as an answer to the low level of output on emergent farms. Very few farmers would pay attention to extension workers if they do not have the necessary resources to purchase recommended inputs. Since the two farm groups are equally economic-efficient and operate under constant returns to scale, their ability to utilize additional inputs is the same. Because emergent and commercial farmers are not absolute price-efficient, improved extension services could make a significant contribution. It would assist both farm groups in getting input demand function parameters closer to the corresponding parameters in the profit function.

The history of the maize industry indicated that emergent farmers face different constraints in the capital market than commercial farmers. Lack of assets to secure loans increase the risks associated with loan recovery. Since the government controls interest rates, private banks cannot increase interest rates on agricultural loans to offset the risks of unsecured loans. This may have discouraged private banks from extending loans to most emergent farms. This feeling has been partially fueled by insecure land tenure based on communal ownership. Because most emergent farms are on communal land, land cannot be used as security, thus they are often excluded from bank loans. If economic efficiency is used as the basis for the allocation of resources, then results from this study indicate that both farm groups should have equal access to loans. This implies that it may be necessary to explore ways of eliminating controls on interest rates, so that private banks could charge the full cost of credit. This would help increase the pool of loanable funds, thus enable many more farmers to obtain loans. Alternatively, laws may be changed to permit land ownership, so that it could be used as security on loans. Since there is bound to be some resistance to changes in land ownership, traditional leaders have to be involved in drafting laws. If land ownership laws and interest rate reforms are implemented simultaneously, they would moderate the rise in interest rates.

Research has produced maize cultivars suitable for different microclimatic conditions, thus making it possible to grow maize in many areas of Zambia. The problem is access to these cultivars and the complementary inputs. This study indicates that commercial farms may be more technical-efficient than emergent farms. Since most farmers do not have cash to meet additional costs, credit may be a major constraint. This is related to the areas that can be planted and the levels of the different inputs to be used. In addition to the availability of credit, different inputs have to be available in areas where farms are located and farmers must earn a good return from their produce.

Lack of sufficient equity and credit capital implies that emergent farms are smaller than commercial farms. This was confirmed by the descriptive statistics. Both commercial and emergent farms operate under constant returns to scale. This means that efficient farms could occur in a wide range of sizes. The farms having access to credit capital are generally larger than those with no credit. Constant returns to scale and equal economic efficiency may invalidate the arguments for large farms (e.g., state and cooperative farms). Because commercial and emergent farms are equally economic-efficient, focusing on emergent farms to increase maize production cannot result in economic efficiency loss. However, such a policy could help in the redistribution of income. Commercial farmers are well established and should be encouraged to obtain credit and other resources without government assistance.

Fertilizer appears to be most important in determining short run profitability. If fertilizer is increased by 10 percent, maize output and profit may expand by 3.1 percent (3.1%). The next important variable is other cash expenditures. A 10 percent increase in other cash expenditures would increase maize supply and profit by 1.8 percent (1.8%). Hired labor is the least significant variable and is negatively related to profit. A 10 percent increase in the quantity of hired labor would expand maize output and profit by 0.27 percent (0.27%). Among fixed inputs, harvested area is the most influential in expanding maize supply and profit (4.6 percent per 10% change). If area expansion is used to expand maize supply, it would require an increase in the quantities of non-land capital and variable inputs. However, scarcity of non-land capital may limit area expansion. Since commercial farms depend on non-land capital more than emergent farms, their ability to increase maize supply is constrained. A 10 percent increase in family labor could expand profit and maize supply by 1.9 percent. Because family labor is the major resource on most emergent farms, it could be a crucial input if emergent farms became the focus of increased maize production. Reliance on emergent farms could eliminate the need for expensive machinery. Therefore, any policy to raise maize production could lead to increased use of inputs. Because more variable inputs would be needed, imports of inputs which are not produced in Zambia may increase.

The descriptive analysis of maize production indicated that emergent farms use smaller quantities of inputs per acre. As a result of this, much of the potential of maize hybrids (for raising production and incomes) has remained largely unexploited. The yields are directly related to the level of inputs used. When smaller than recommended quantities of inputs are used, maize supply could decrease by 3.10% for fertilizer, 1.80% for other cash, and 0.27% for hired labor, per 10% change in the respective input. Since small quantities of inputs reduce yield per acre, farmers offset some of the loss by paying increased attention to other cultural practices. If the full potential of maize hybrids is to be exploited, then the farmer has to meet increased cash costs. Once excluded from credit capital, emergent farmers turn to the traditional means of production and/or use small quantities of purchased inputs. Without a good return over what they produce, farmers may decide not to buy inputs to increase production or take steps to preserve the soil fertility.

Because the private sector and past policies have helped establish commercial farmers, government policy may focus on channelling adequate equipment (oxen), credit, and inputs to emergent farmers. Emergent farmers depend on family labor to perform all cultural practices while commercial farmers depend on non-land capital. Capital intensive techniques expand employment less rapidly. This means that by encouraging emergent farmers to raise production, a large proportion of the labor force could be absorbed. Therefore, based on equity, domestic resource use, economic efficiency and constant returns to scale arguments, the policy of encouraging emergent farmers may be proper. Commercial farms need help to improve their allocative efficiency, i.e., determining optimum input mix.

8.2 CONCLUSIONS

Low maize prices and inadequate access to some inputs may be partly responsible for the failure to raise maize production (EEC [1980], World Bank [1984a, b]). High maize prices are needed to encourage use of improved seeds, purchased inputs and improved cultural practices (Brown [1978]). These help to increase the efficiency of resource use. An efficient capital market is needed to provide credit to finance purchased farm inputs.

One way of increasing maize production is through better use of existing inputs. This study indicates that emergent and commercial farms are not absolute price-efficient, thus policies to improve management could enable farmers to maximize profit. Because all farms receive the same price per bag of maize and emergent farms are relatively more price-efficient than commercial farms, the marginal physical products of emergent farms may be greater than commercial farms. Therefore, returns to additional resources is greater on emergent farms. This implies that extension programs designed to improve emergent farm management may be ineffective for they already utilize resources better than commercial farms.

Another way of increasing maize production is through employing more variable inputs. Since the technical efficiency of emergent farms was less than that of commercial farms, it may be targeted for improvement. This study indicated that emergent farms use less than recommended quantities of inputs, thus it is necessary to ensure that additional resources are available. This would enable emergent farms to utilize the production potential of hybrid seed. Because many farms do not have cash to meet the additional costs of hybrid maize production, there is need to evaluate ways of increasing the pool of loanable funds.

Maize production could be increased through development and use of more productive cultivars of maize. The number of cultivars available for different micro-climatic conditions suggest that technology to increase maize production is available. The problem is that only a few farms have full access to this technology. Other farmers either have partial or no access to hybrid seed and the complementary inputs. This implies that there is need to ensure local availability of all inputs and improve access to credit.

In order to achieve the above suggestions, it may be necessary to introduce changes in institutions which set policy and provide services to farmers. These changes ought to ensure that proper incentives (e.g., high prices of maize) and services (e.g., marketing) are available at the right time. The World Bank [1984b] and EEC [1980] concluded that institutional changes are crucial to increased maize production. From this study, it is clear that much of the potential for output growth and the resulting income benefits have not yet been realized from maize hybrids. While many emergent farmers have adopted maize hybrids, their full utilization has not been attained. By applying larger quantities of fertilizer, emergent farmers could increase maize supply by 3.11 percent for each 10% increase in fertilizer. This would bring the rate of growth of maize supply in line with the growth of the population (about 3.1% per year, CSO [1985]). The low levels of fertilizer application indicate a shortage of equity and credit capital

Emergent farmers produce 60 percent of marketed maize but only use a small fraction of the subsidized inputs. Because emergent farmers are relatively poorer than most consumers, it an inequitable income transfer. To address the disparities in the distribution of benefits from past policies, institutions have to be encouraged to deliver services efficiently. This may mean institutional reforms, e.g., encouraging competition in the marketing of inputs and maize. Because of what could be gained, the government can contribute through direct (e.g., providing loans in areas where private banks do not operate) and indirect (e.g., tax incentives on loans to agriculture) intervention with a view to improving services to emergent farmers. Certain sectors (e.g., capital market) have not benefited from government intervention, thus it is necessary to examine ways of improving the performance of such areas. Even though this study did not examine ways of improving the capital market, the suggestions put forward by Dale and Graham [1981] to improve the performance of agricultural lending institutions are a good starting point. They argued that lending institutions need: stable and positive real interest rates, programs to mobilize rural savings, incentives to encourage them to increase funds for agricultural loans, and macro policies which do not contradict saving incentives. In addition, they argued that farmers need freedom to use debt capital in any agricultural enterprise they find profitable (rather than linking it to a specific crop). They conclude that these are not a cure to all problems, but the reforms could lead to significant gains in resource allocation and distribution of loanable funds.

The overall solution requires evolving policies (e.g., encouraging some competition in marketing to improve delivery of services) and institutions to effectively ensure the availability of inputs and credit to emergent farmers on reasonable terms. Some institutions which serve farmers (especially emergent farmers) have lagged behind (e.g., AFC) and thus need improvement so that they could respond to the changing production environment (World Bank [1984a]). Many studies (World Bank [1984a, b], EEC [1980], and Jansen [1986]) have found that some government institutions are inefficient (e.g., their services are either late or inadequate). They recommend reduction of delays and management improvement.

In terms of the previous studies, results from the current work support those which have reported equal economic efficiency and conclude that increased maize production ought to come from emergent and commercial farms. Therefore, differences in resource endowments do not influence economic efficiency. The need to increase food production will continue to be important. Evidence from this study indicates that support for both farm groups is appropriate. Because commercial farms are relatively less price efficient, extension workers may target them for management improvement. Since emergent farms are less technical efficient, access to additional inputs could enable them to utilize the potential of hybrid maize. This could imply increased access to credit and adoption of measures that affect the profitability of the maize enterprise (e.g., producer prices which reflect opportunity cost)

As pointed out, current world market conditions do not favor maize exports from Zambia. This is because of competition from the USA and other producers, rapid rise in the world maize area, and the fact that Zambia appears to be a high cost producer of maize (World Bank [1984a]). Another factor is that almost all exporters of maize subsidize their maize exports. The other problem is that some of the neighboring countries (Malawi and Zimbabwe) produce surplus maize, further affecting the market in the region. However, the new hybrids could change the potential for export, i.e., new low cost cultivars could emerge and change the comparative advantage. Until then, policy should focus on being self-sufficient in maize and ensuring that there are adequate stocks to offset any shortfall in maize production.

The objective of government policy is to increase maize production. Raising the incomes and profits of farmers may create incentives to produce more. Besides the price of maize, the other crucial factors are increased fertilizer application and the spread of hybrid seeds. Thus, the fertilizer industry has a crucial role to play. The local fertilizer plant does not meet existing demand. Therefore, fertilizer is imported to meet the shortfall. Transportation problems delay arrival of imported fertilizer. If fertilizer is not used at the right time, yields tend to be low. This implies that there is need to explore policies to expand domestic production of fertilizer.

Because land is not scarce, expansion of the farm area may appear to be a feasible option. The problem is that expansion of the farm size requires substitution of capital for labor.[35] Even though there is no shortage of labor, the problems associated with managing a large labor force and timeliness of cultural practices could encourage large farms to substitute capital for labor. On smaller sizes of farms, this is not likely to be a big problem, thus they could be more labor intensive. Foreign exchange constraints, the need to create jobs on many small farms and the possibility of widely raising farm incomes could block the area expansion option. Even if farm areas expand, there is need for increased fertilizer to maintain or improve soil fertility.

Considering all existing constraints, the most feasible way of raising maize production in Zambia is through more intensive use of the land under cultivation. Under this approach, increased production is achieved through use of hybrid seed, proper cultural practices, fertilizer, herbicides and insecticides. Even though there is bound to be an increase in foreign exchange requirements to import some of these inputs, reduced reliance on imported machinery would make intensive approach cheaper than the extensive alternative.

Efforts must be made to lower the non-land capital requirements. This is because of the foreign exchange problems and the declining exchange rates which make imported inputs expensive. Policy should encourage relatively low demands for imported inputs, offer maize prices

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[35] Jonsson [1977] reported that hand tools are adequate for farm sizes less than five acres. He found that oxen use was adequate for areas between five and 50 acres. For areas greater than 50 acres, tractor use was recommended. Therefore, as farm size increases there is increased reliance on capital inputs.

which reflect opportunity cost, provide relatively cheap fertilizer, improve credit and marketing institutions, and improve extension services.

This study has raised questions about some of the current policies. There is some distance before full exploitation of the potential of maize hybrids. Institutional reforms have not kept pace with the technology of maize hybrids. Yet the results indicate that given proper policy, it is possible to increase maize production. In the following section, areas in which further research might be helpful are identified.

8.3 SUGGESTIONS

Many studies have recommended that the price of maize be increased to attract investment. There is need to study how to phase out distortions in the input, output and capital markets. Because some consumers may be adversely affected, studies are needed to determine how the poorest consumers could be directly assisted.

It is necessary to specify the institutional biases which determine access to credit capital. This requires a careful analysis of the incidence of benefits from institutional reform and pin pointing why current institutions have failed. In addition, there is need to identify efficient ways of delivering credit to farmers.

Research is needed to establish the cost functions and the production process for maize. This means that data have to be collected and analyzed. Data must be presented in budget form, covering as many micro-climatic regions as possible rather than for farm groups. Such information could assist reformed lending institutions in loan evaluation. The problem is that records are not kept. This means that the farmer's memory will continue to be the major source of information. Information obtained this way may be suspected. Where possible, efforts have to be made to encourage record keeping.

The education variable failed to display the expected influence on profit. In future, it may be appropriate to use years of schooling of the farm operator as a proxy for education. Finally, it may be useful to estimate cross section equations every few years (e.g., 5 years apart). The estimated coefficients from one cross section to another could indicate whether the period under consideration is stable or in transition. This is appropriate for evaluating the influence of new technology and policies.

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Appendix A

HISTORICAL PRODUCTION DATA

TABLE 24

Total Marketed Production of Maize 1964/73

Year	Acreage Planted	Production ('000)*	Yield Per Acre*	Marketed Production*	Price (K) per Bag	Surplus ('000)*	Deficit*
1964	92159	2139	15.83	1459	3.45	200	0
1965	127594	2804	19.22	2452	3.45	620	0
1966	177072	4163	16.13	2857	3.32	1901	0
1967	139400	4131	20.39	2828	3.10	1583	0
1968	87858	2748	19.73	1733	2.90	0	180
1969	83100	2791	19.61	1630	3.20	0	408
1970	105200	1371	11.69	1230	3.50	0	2436
1971	187284	4109	21.94	2878	4.00	265	0
1972	188600	6851	21.54	4120	4.30	2992	C
1973	191200	n.a.	15.44	2953	4.30	n.a.	n.a.

Note: *Maize is measured in 90 Kg bags

n.a. means that data was not available.

Source: FAO Report; Agriculture Marketing and Pricing Policies, Edited by D. R. N. Brown, MAWD, Lusaka (1973) P10.

TABLE 25

Maize Imports and Exports 1970/82

Year	Imports 90 Kg Bag ('000)	Exports 90 Kg Bag ('000)	Net Import Exports 90 Kg Bag ('000)
1970		0.11	0.11
1971		89.56	89.56
1972		12.11	12.11
1973		555.67	555.67
1974		1222.67	1222.67
1975	433.33	178.44	(267.11)*
1976	277.78	89.78	(178.00)
1977	4456.22	278.44	(4177.78)
1978	244.44	667.67	423.22
1979	788.89	0.00	(788.89)
1980	2634.22	0.00	(2634.22)
1981	1089.33	0.00	(1089.33)
1982	2444.56	0.00	(2444.56)

Note: *The figures in brackets are negative, i.e., the amount was imported to meet domestic demand.

Source: World Bank Report: Policy Options and Strategies for Agricultural Growth, June (1984a), P77.

TABLE 26

Maize Exports From Zambia

90 Kg Bags ('000,000)

Year	EXPORTS TO Zaire	Tanzania	Angola	Mozambique	TOTAL EXPORTS
1973	0.50				0.50
1974	0.47	0.77			1.24
1975	0.18				0.18
1976					
1977	0.05		0.20		0.25
1978	0.45		0.24		0.69
1979					
1980					
1981					
1982					
1983					
1984					
1985					
1986					

Source: Minster Agriculture Limited: EEC-Zambia Project, Development of Maize Production in Kabwe Rural and M'kushi Districts, Vol. 1, July, 1980.

TABLE 27

Zambia - Agricultural Produce Prices

(Kwacha)

Harvest Year	Unit	1970	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
CEREALS													
Maize	90 Kg	3.50	4.30	5.00	6.30	6.30	6.80	9.00	11.70	13.50	16.00	18.30	24.50
Wheat	90 Kg	-	-	16.00	16.00	16.00	20.00	20.00	20.00	26.00	32.00	35.75	42.50
Paddy Rice	80 Kg	-	12.00	12.00	14.40	14.40	14.40	16.00	18.00	18.60	28.00	40.00	40.00
Sorghum	90 Kg	4.70	5.00	6.00	6.00	6.00	6.00	6.00	6.00	9.00	9.00	16.00	18.00
Millet	90 Kg											29.00	29.60
Barley	90 Kg											35.75	42.50
Cassava	1 Kg											0.15	0.20
OIL EXPRESSING SEEDS													
Soy Bean	90 Kg	3.20	13.20	13.20	17.00	17.00	21.50	25.00	32.00	36.30	42.31	45.30	52.50
Sunflower	50 Kg	2.45	8.95	9.40	10.00	10.00	12.50	13.70	16.40	17.60	20.75	21.50	21.50
Groundnuts (shelled)	80 Kg	10.20	17.00	17.00	25.00	25.00	28.60	32.00	35.00	42.70	48.00	52.00	65.00
Seed Cotton	1 Kg	0.08	0.25	0.30	0.40	0.40	0.46	0.46	0.46	0.46	0.47	0.52	0.58
Virginia Tobacco	1 Kg	0.63	0.99	0.81	1.00	0.98	1.29	1.51	1.57	1.65	2.40	2.70	2.80
Sugarcane	MT	6.60	8.40	8.90	10.90	10.90	12.30	13.47	18.00	n.a.	n.a.	n.a.	n.a.
Fresh Milk	1 lr	0.08	0.10	0.11	0.15	0.15	0.21	0.24	0.23	0.28	0.43	0.47	0.52
BEEF CATTLE	head	83.97	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	251.00	273.00	n.a.	n.a.

Source: World Bank, Policy Options and Strategies for Agricultural Growth in Zambia, 1984a, p.101.

TABLE 28

Zambia - Exports of Principal Commodities, 1970 - 1982

(Millions of Current Kwacha and Thousands of Tons)

Item	1970	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
MILLIONS OF CURRENT KWACHA											
Copper	681.4	698.3	838.5	472.0	688.6	597.7	897.7	897.2	872.4	835.7	856.0
Zinc	11.0	16.7	25.2	20.3	26.6	17.9	17.6	27.1	19.6	22.9	25.0
Lead	4.9	5.4	7.2	5.7	4.4	5.7	3.3	6.1	6.5	5.1	4.0
Cobalt	6.3	4.9	7.9	7.1	15.9	16.2	36.7	129.9	87.5	39.0	30.0
Tobacco	2.9	4.8	5.8	5.0	5.1	5.8	3.5	2.6	2.7	4.0	2.0
Maize	-	2.6	7.6	1.4	0.5	3.5	7.8	-	-	-	-
Electricity		0.3	-	1.5	0.3	-	10.6	-	-	-	-
Other Goods	8.5	9.0	8.1	5.0	7.4	12.2	8.1	24.7	34.6	22.8	30.0
TOTAL EXPORTS	715.0	742.0	900.4	518.0	748.8	706.4	685.3	1,087.6	1,023.3	929.5	949.0
Re-Exports	4.6	4.0	4.7	3.1	3.1	1.6	1.5	3.4	2.8	6.9	5.0
Adjustments	-46.4	-12.5	-6.9	-4.9	-9.5	-7.2	-21.7	26.6	125.9	-70.1	-76.0
Valuation Adjustments & Change in Stocks Held Abroad	-	-	-	-	-26.4	-15.8	-36.7	11.6	110.3	-84.6	-91.0
Freight & Insurance on Metal Exports to Zambian Border	-	-	-	-	16.9	8.6	15.0	15.0	15.2	14.5	14.0
Exports F.O.B. (B.O.P.)	673.2	733.5	898.2	516.2	742.4	700.8	665.1	1,117.6	1,152.0	866.3	877.0
THOUSANDS OF TONS											
Copper	684.0	670.0	673.4	641.2	745.7	666.6	589.2	651.8	621.7	551.8	-
Zinc	50.3	51.0	50.2	41.3	51.2	36.5	35.4	42.1	30.8	-	-
Lead	22.1	20.0	18.8	19.4	14.8	11.7	6.6	8.5	8.7	-	-
Cobalt	1.8	1.1	1.9	1.3	2.3	1.7	1.8	3.1	1.9	2.2	-
Tobacco	4.0	5.0	4.9	5.3	4.6	3.4	1.6	1.6	2.6	-	-
Maize	0.1	50.1	111.2	16.6	8.8	25.6	61.0	-	-	-	-

Source: World Bank, Issues and Options for Economic Diversification in Zambia, 1984b, p.79.

TABLE 29

Zambia - Marketed Agricultural Production

Metric Tones

Harvest Year	1970	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
CEREALS													
Maize ('000)	132	588	559	750	696	582	336	382	693	508	531	571	918
Wheat	-	-	934	3,948	5,324	5,251	6,528	9,584	11,478	n.a.			
Paddy-rice	93	357	1,009	2,093	1,860	2,925	1,852	2,213	2,673	n.a.			
OIL EXPRESSING SEEDS													
Soy Bean	-	37	367	604	1,274	1,187	1,295	3,531	3,673	n.a.			
Sunflower ('000)	-	4	8.2	16	13.3	7.6	11.9	17.2	19.2	20.3			
Groundnuts (shelled)	3,601	3,626	6,499	9,467	7,462	2,234	2,737	2,028	1,320	704			
Seed Cotton ('000)	5.4	2.2	2.6	3.9	8.9	8.4	14.9	22.9	16.7	12.8			
Sugar Cane ('000)	321	570	768	780	691	775	888	920	893	1,010			
Virginia Tobacco ('000)	4.8	6.3	6.5	6.3	5.6	3.7	4.6	4.1	2.3	1.9			
Barley Tobacco	388	501	502	212	311	264	381	554	665	704			
Roasted Coffee	6	11	24	33	44	77	24	28	40	n.a.			
Tea Leaves	-	-	-	10	81	144	249	314	n.a.	n.a.			
Fresh Milk ('000)	45	49.5	50	48	48	50.2	53.2	53.7	55.3	n.a.			
BEEF CATTLE (Head, 000's)													
Total Slaughterings of which	68.4	80.1	71.7	77.6	71.5	67.7	88.6	92.4	100.1	n.a.			
Cold Storage Board	35.9	28.0	18.2	18.7	23.9	18.9	19.7	15.9	13.8	n.a.			
Pig Slaughterings	31.9	44.3	55.5	50.2	35.8	42.4	48.4	47.9	37.7	n.a.			

Source: World Bank, Policy Options and Strategies for Agricultural Growth in Zambia, 1984a, p.102.

Maize data has been updated with information from Agricultural Statistical Bulletin, September, 1985.

TABLE 30

Zambia, Commitments, Disbursements and Service Payments on External Public Debt

(In Millions of U.S. Dollars)

	Debt Outstanding At Beginning of Period		Transaction During Period				
					Service Payments		
Year	Disbursed Only	Including Undisbursed	Commitments	Disbursements	Principal	Interest	Total
1970	326.1	433.6	555.3	350.6	32.7	26.3	59.0
1971	622.5	931.6	9.4	41.8	43.4	34.7	78.1
1972	632.8	910.8	146.0	131.8	75.8	36.7	112.5
1973	676.3	982.5	427.1	293.9	277.8	90.8	368.6
1974	703.7	1,163.9	279.3	172.3	67.1	47.3	114.4
1975	815.9	1,377.7	346.3	432.0	49.2	62.4	96.9
1976	1,155.7	1,611.8	209.7	228.9	60.0	62.4	122.4
1977	1,305.8	1,741.5	149.6	182.0	130.2	66.0	196.3
1978	1,406.5	1,819.7	420.4	154.5	165.4	76.5	241.9
1979	1,470.1	2,119.7	695.9	535.5	174.9	82.3	257.2
1980	1,848.2	2,657.4	667.4	623.9	185.5	107.7	293.2
1981	2,205.1	3,024.2	412.5	402.3	190.4	94.4	284.7
1982	2,254.6	3,021.2	431.9	349.2	101.7	86.6	190.2
1983	2,394.1	3,155.6	117.3	157.7	46.9	79.3	126.2
1984	2,635.3	3,300.5					
---The Following Figures are Projected---							
1984	2,635.3	3,300.5	-	238.4	285.7	135.4	421.1
1985	2,363.5	2,790.3	-	164.2	282.3	122.6	404.9
1986	2,245.4	2,508.0	-	108.0	277.1	107.9	385.0
1987	2,076.3	2,230.9	-	67.0	252.7	92.0	344.8
1988	1,890.5	1,978.1	-	40.6	221.4	76.1	297.5
1989	1,709.7	1,756.6	-	21.8	163.7	64.3	228.1
1990	1,567.8	1,592.9	-	13.6	140.1	55.2	195.4

Note: Figures for each year are based on exchange rate prevailing at the end of each year, respectively. Changes in amounts outstanding and disbursed are affected by fluctuations in exchange rates and by cancellations and, therefore, do not equal disbursement minus repayments.

Source: World Bank, Issues and Options for Economic Diversification in Zambia, 1984b, p.87.

TABLE 31

Guaranteed Prices and Marketed Maize

Year	Guaranteed Maize Price (K)	Bags Marketed - 90 Kg bag
1964 - 1965	3.45	2,202,360
1965 - 1966	3.72	2,864,493
1966 - 1967	3.32	4,300,256
1967 - 1968	3.10	4,233,877
1968 - 1969	2.90	2,856,482
1969 - 1970	3.20	2,930,730
1970 - 1971	3.50	1,468,972
1971 - 1972	4.00	4,265,492
1972 - 1973	4.30	6,539,157
1973 - 1974	4.30	4,435,019
1974 - 1975	4.30	6,534,333
1975 - 1976	5.00	6,216,455
1976 - 1977	6.30	8,333,022
1977 - 1978	6.30	7,738,347
1978 - 1979	6.80	6,462,847
1979 - 1980	9.00	3,732,879
1980 - 1981	11.70	4,247,404
1981 - 1982	16.00	5,705,578
1982 - 1983	18.30	5,901,824
1983 - 1984	24.50	6,347,637
1984 - 1985	28.32	7,069,637
1985 - 1986	55.00	10,200,000

Source: Jansen D. J., A Comparative Study of the Political Economy of Agricultural Pricing Policies in Zambia, 1986.

Data has been updated with information from MAWD data, 1986.

TABLE 32

Zambia Wholesale Price Indices

Item	Weights	1970	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
WHOLESALE PRICE INDICES (1966 = 100)												
1. BY END USE												
All Domestically Used Goods	535	116.4	161.7	188.6	221.6	276.2	330.2	381.9	424.2	475.9	542.8	663.0
Consumer goods	263	122.4	166.4	191.9	211.9	251.8	283.6	309.7	356.1	393.1	455.7	558.5
Goods for FIX. CAP. FORMAT	133	109.0	156.9	190.8	253.4	320.6	413.6	487.3	544.8	599.5	688.1	834.6
Goods for further process	139	112.2	157.4	180.4	209.9	279.8	338.5	417.7	437.7	514.2	568.5	696.6
Export Goods	465	113.0	151.1	99.2	122.9	137.3	149.9	219.2	230.9	209.7	183.0	223.9
All Goods	1,000	114.7	156.8	147.0	175.7	211.6	246.4	306.2	334.3	352.1	375.5	458.8
2. BY INDUSTRIAL ACTIVITY												
Agriculture	82	113.9	140.6	164.1	176.5	204.3	245.2	270.6	316.0	409.6	472.9	580.0
Mining	459	113.2	151.1	97.6	122.1	135.9	152.0	216.6	227.0	202.8	174.3	221.8
Copper mining	428	112.8	143.6	90.0	113.5	124.3	129.8	182.8	194.2	171.1	153.2	203.7
Manufacturing	443	117.2	168.3	197.3	234.4	296.0	350.5	414.0	458.2	493.5	576.6	695.7
Electricity	16	95.7	85.6	84.0	86.9	83.5	79.7	79.1	77.4	78.1	80.2	-
Total non-copper	572	116.2	166.6	189.7	222.3	276.9	333.7	398.6	439.2	487.5	541.9	-
All commodities	1,000	114.7	156.8	147.0	175.7	211.6	246.4	306.2	334.3	352.1	375.5	458.8
3. P. index of building materials (1974 = 100)	-	-	100.0	104.2	125.3	141.5	165.3	188.8	205.5	230.7	-	-

Source: World Bank, Policy Options and Strategies for Agricultural Growth in Zambia, 1984a, p.111.

TABLE 33

Percentage of Loan Disbursements to Farmers by End Use

Items	1975/76 %	1976/77 %	1977/78 %	1978/79 %	1979/80 %	1980/81* %	1982/83 %**	1983/84 %
Crop Inputs	77.0	74.1	73.9	67.0	61.5	58.3	45.29	82.73
Dairy Cattle	2.6	1.5	0.9	1.8	2.8	3.9	2.24	0.41
Beef Cattle	6.5	4.7	4.9	7.9	8.5	11.8	3.54	4.96
Pigs	0.8	1.4	0.7	0.8	0.9	2.0	0.45	0.24
Poultry	1.4	1.8	2.0	2.1	1.6	1.9	1.85	0.82
Other Livestock	0.1	0.1	1.5	0.2	0.2	0.7	0.85	0.14
Agric. Machinery (purchase & repair)	7.2	8.0	6.2	7.1	12.9	13.0	31.21	5.30
Land (purchase & improvement)	3.4	2.9	1.2	1.6	3.2	2.6	1.51	1.04
Farm Infra-structure (new & improvement)	0.8	0.7	0.5	1.9	1.2	1.6	1.89	0.40
Other	0.2	4.8	8.2	9.6	7.2	4.2	11.18	3.95
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.00	100.00

Note: * Data for the 1981/82 season is not available
** Percentage for crops decreased so that more resources could be allocated to the replacement and repair of machinery.

Source: World Bank [1984a], p.238.
Data has been updated with information from MAWD [1986], p.40.

Appendix B

QUESTIONNAIRE

QUESTIONNAIRE USED IN THE 1986 CROSS SECTION SURVEY

The pages which follow contain questions about farming practices. The information provided will be kept confidential and will be combined with other farms so that it is impossible to know your answer. This data is important in gaining a better understanding of maize production.

Farmer's Name: ....

Farm Number: ....

Location of farm: ....

Date: ....

Interviewer: ....

Total number of acres planted with all crops:

1)............................ 4)............................

2)............................ 5)............................

3)............................ 6)............................

Total area cleared: ....

Total value of improvement on the maize fields:

Land clearing: ....

Fencing: ....

Grain building: ....

FAMILY AND RELATIVES WORKING ON THE FARM

Name of Person	Sex	Age	No. of Years Spent in School	Tasks Performed on the Farm	Days Spent on the maize farm

LABOR PROFILE FOR MAIZE

Task	Number of Family members involved	Number Relatives involved	Minimum Payment to Induce farmer to work for others
Tractor ploughing			
Disc harrowing			
Cultivating			
Basal dressing			
Planting			
Top dressing			
Spraying chemical(s)			
Harvesting maize			
Transporting inputs			
Transporting maize			
Non-farm job			

HIRED LABOR PROFILE FOR MAIZE

Task	Number of Workers	Rate per Task	Days Hired	Total Payment		
				Money (K)	Food (Bags)	Room (Rent K)

INVENTORY OF MACHINERY

Number of Oxen: ....

Number of Ox-ploughs: ....

Number of Ox-planters: ....

Number of Ox-cultivators: ....

Number of Ox-harrow: ....

Number of Scotch carts: ....

Number of hand shellers: ....

Number of Ox-ridgers: ....

Number of tractors: ....

Number of ploughs: ....

Number of disc harrows: ....

Number of fertilizer spreaders: ....

Number of planters: ....

NUmber of trailers: ....

Number of sprayers: ....

Number of shellers: ....

Number of combine harvesters: ....

Number of trucks: ....

Number of hammer mills: ....

Other equipment: ....

....

....

OWNED MACHINERY DESCRIPTION
(for Maize Enterprise)

Name of Machinery	Age	Year Purchased	Size	Purchase Price (K)

Total machinery insurance costs:

....

....

....

Total fuel and lubricant costs:

....

....

....

....

....

....

RENTED OR BORROWED MACHINERY (SERVICES)

				Cost		
Name of Machinery (or service)	Size	Task Performed	Days Used	Money (K)	Food (bags)	Labor Days Exchanged for service

Rented:

Borrowed:

MAIZE CROP PRACTICES

	Maize No. 1	Maize No. 2	Maize No. 3
1. Maize field number(s):			
2. Insurance			
Crop insurance premiums(K/acre)	....	....	....
Expected insurance claims(K/acres)	....	....	....
3. Location			
Distance from field to farm storage (Km)	....	....	....
Distance from farm storage to the nearest market (Km)	....	....	....
4. Size			
Number of acres planted	....	....	....
5. Yield			
Yield of maize (bags/acres)	....	....	....
Total yield of maize (bags/field)	....	....	....
Total bags sold	....	....	....
Price per bag received (K)	....	....	....
Total bags stored	....	....	....
Total bags eaten (or used as feed)	....	....	....
Total bags used as gifts	....	....	....
6. Seed Class			
Local, or Hybrid (MM 752, MM 504, MM 601, MM 603, MM 604, MM 606, SR 52) or part of hybrid maize harvest kept as seed	....	....	....
Cost of seed (K)	....	....	....
Seeding rate (plants per acre or bags per acre	....	....	....
When did you plant (Date)	....	....	....
Number of crops inter-cropped on	....	....	....

	Maize No.1	Maize No.2	Maize No.3
7. Fertilizer			
Number of bags used in basal dressing	....	....	....
Total cost of basal dressing	....	....	....
Number of bags used in top dressing	....	....	....
Total cost of top dressing	....	....	....
8. Chemicals			
Name of herbicide used	....	....	....
Amount of herbicide used (Kg bag)	....	....	....
Cost per bag (unit) (K)	....	....	....
Portion of field sprayed (%)	....	....	....
Name of insecticide used	....	....	....
Amount of insecticide used (Kg)	....	....	....
Cost per bag (unit) (K)	....	....	....
Portion of the field sprayed (%)	....	....	....
Name of fungicides used in storage	....	....	....
Amount of fungicide used (Kg)	....	....	....
Cost per bag (unit) (K)	....	....	....
Portion of field sprayed (%)	....	....	....
9. Tractor or Equipment days required			
Days needed to plough	....	....	....
Days needed to disc harrow	....	....	....
Days needed to cultivate	....	....	....
Days needed to ridge	....	....	....
Days needed to spread fertilizer top	....	....	....
Days needed to plant and basal	....	....	....
Days needed to combine harvest maize	....	....	....
Trips needed to transport maize	....	....	....

GENERAL

	Agree	Disagree
1. Do you like farming?	....	....
If yes, why?		
Ans: Profitable	....	....
Grow my own food	....	....
Work as I like	....	....
Custom (or way of life) and business	....	....
No alternative	....	....
2. If no, why?		
Ans: Hard work	....	....
Unprofitable	....	....
Dislike living in rural areas	....	....
3. Other businesses or jobs besides the farm		
Ans: Shop	....	....
Fish trading	....	....
Transportation	....	....
Employment	....	....

		Agree	Disagree
4.	Indicate the one you prefer most (only one)		
Ans:	Farming		
	Shop		
	Fish trading		
	Transportation		
	Employment		
5.	Why do you prefer the above?		
Ans:	More profitable	....	....
	Income is steadier	....	....
	Can grow own food	....	....
	Work as I like	....	....
6.	What are the factors that prevent you from making more money in farming?		
Ans:	Low maize yields	....	....
	Low prices received	....	....
	High input costs	....	....
	Non-availability of loans	....	....

	Agree	Disagree
7. Why are you not growing more maize?		
Ans: Insufficient labor	....	....
No tractor and equipment	....	....
Insufficient money to buy inputs	....	....
Transportation difficulties	....	....
Land is too small	....	....
No oxen and Ox ploughs	....	....
Low maize prices	....	....
8. Do the following improve production skills?		
Ans: Radio and T.V.	....	....
Papers, books	....	....
Community meetings	....	....
Political meetings	....	....
Farmer meetings	....	....
Farmer training courses	....	....
School	....	....
Ministry of Agriculture	....	....
9. Do the following buy your maize?		
Ans: Cooperatives	....	....
NAMBOARD	....	....
Private traders	....	....
Other organizations	....	....

10. Which one do you prefer and Why?

....

....

....

....

	Agree	Disagree
11. Hybrid seed was not used because		
Ans: It is not available	....	....
No money	....	....
No credit	....	....
Too expensive	....	....

12. Fertilizer was not used because

Ans: It is not available	....	....
No money	....	....
No credit	....	....
Too expensive	....	....

Appendix C

ELASTICITIES OF INPUTS

DERIVING ELASTICITIES OF INPUTS

Following Lau and Yotopoulos [1972], input elasticities (in section 7.1) are derived based on the profit function:

$$NR^* = A \prod_{j=1}^{m} (C_j)^{\beta_j^*} \prod_{t=1}^{n} (Z_t)^{\beta_t^*}$$

Where

NR^* = Normalized net revenue (NR/P)

P = Price of maize

A = Technical parameter

C_j = Price of variable input, $j = 1,2,...m$

Z_t = Fixed inputs $t = 1,2,...n$

and input demand functions

$$-C_j X_j / NR^* = \beta_j^*$$

$$X_j = \frac{-\beta_j^* \; NR^*}{C_j}$$

$$\ln X_j = \ln(-\beta_j^*) + \ln NR^* - \ln C_j$$

Where

X_j = Variable inputs $j = 1,2,...m$

Then, the input demand elasticity with respect to the variable input price is:

$$\frac{\delta \ln X_j}{\delta \ln C_j} = \frac{\delta \ln NR^*}{\delta \ln C_j} - 1$$

$$= \beta_j^* - 1$$

The input demand elasticity with respect to the fixed input is:

$$\frac{\delta \ln X_j}{\delta \ln Z_t} = \frac{\delta \ln NR^*}{\delta \ln Z_t}$$

$$= \beta_t$$

To examine the impact of different policies on maize supply, Lau and Yotopoulos[1972] suggested that output (V) is given by:

$$V = NR^* + \sum_{j-1}^{m} C_j X_j$$

But

$$\beta_j^* = -C_j X_j / NR^*$$

$$C_j = -\beta_j^* NR^* / X_j$$

Through substitution

$$V = NR^* \left(1 - \left(\sum_{j=1}^{m} \beta_j^*\right)\right)$$

Then output response with respect to the variable input price is:

$$\frac{\delta \ln V}{\delta \ln C_j} = \frac{\delta \ln NR^*}{\delta \ln C_j}$$

$$= \beta_j^*$$

Output response with respect to fixed inputs is:

$$\frac{\delta \ln V}{\delta \ln Z_t} = \frac{\delta \ln NR^*}{\delta \ln Z_t}$$

$$= \beta_t^*$$

Output response with respect to the price of maize is:

$$\frac{\delta \ln V}{\delta \ln P} = \frac{\delta \ln V}{\delta \ln C_j} \frac{\delta \ln C_j}{\delta \ln P}$$

$$= \beta_j^*$$