FOOD SECURITY RESEARCH PROJECT

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***WORKING PAPER No.* 50**
FOOD SECURITY RESEARCH PROJECT
LUSAKA, ZAMBIA
March 2011
(Downloadable at:* http://www.aec.msu.edu/fs2/zambia/index.htm *)

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ACKNOWLEDGMENTS

The Food Security Research Project is a collaborative program of research, outreach, and local capacity building, between the Agricultural Consultative Forum, the Ministry of Agriculture and Cooperatives, and Michigan State University's Department of Agricultural Economics.

The authors would like to acknowledge the helpful comments received from Antony Chapoto and other FSRP team members. We also thank the staff and enumerators of FSRP, CSO (Central Statistics Office), and MACO (Ministry of Agriculture and Cooperatives) for their important role in entering, crosschecking, and cleaning the Crop Forecast Survey data. We would like to acknowledge Margaret Beaver for her substantial contribution to the training of enumerators, data entry personnel and data cleaners. We also appreciate the formatting, editing and carallion playing assistance of Patricia Johannes.

We wish to acknowledge the financial and substantive support of the Swedish International Development Agency and the United States Agency for International Development (USAID) in Lusaka. Research support from the Global Bureau, Office of Agriculture and Food Security, and the Africa Bureau, Office of Sustainable Development at USAID/Washington also made it possible for MSU researchers to contribute to this work.

Any views expressed or remaining errors are solely the responsibility of the authors.

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EXECUTIVE SUMMARY

Many agricultural policy discussions in Zambia revolve around the cost of producing maize. Despite the importance of having accurate estimates of production costs, smallholders' cost of maize production in Zambia remain poorly understood. Various estimates are provided by interested parties, but these are rarely based on representative farm surveys that take into account the variations in agro-ecological conditions, input intensities, and rainfall, which can profoundly affect maize production costs.

To provide a better empirical foundation for the derivation of maize production costs in Zambia, the 2010 Crop Forecast Survey (CFS), conducted by the Central Statistics Office and Ministry of Agriculture and Cooperatives, was modified to include specific questions relating to the smallholder's land, labor, and capital costs associated with producing and marketing maize. The 2010 CFS therefore provides the first opportunity to provide estimates of maize production costs for over 10,000 smallholder farmers in Zambia. The objective of this study is to analyze these data to provide policy makers with estimates of the smallholder farmers' cost of maize production in Zambia as well as to identify the factors causing these estimates to vary across the surveyed households

A major topical issue that can be informed with accurate production cost estimates is the price offered to farmers by the Zambian Food Reserve Agency (FRA) each year. The FRA sets its maize buying price each year to compensate farmers for the costs incurred during production and provide a reasonable return to their own land, labor, mechanical, and animal inputs. However, the setting of FRA's producer price has never benefitted from national farm survey evidence on production costs. Rather, illustrative figures are provided by various stakeholder groups to lobby and influence the setting of FRA purchase price levels. For the 2009 and 2010 marketing seasons, this price had been set at Zambian Kwacha (ZMK) 65,000 per 50 kg bag of maize grain.

Our first key observation is that the FRA pan-territorial pricing policy does not reflect the wide geographic differences in costs and even among farmers in the same village. Geographic variation in production costs follow differences in agro-ecological suitability for maize production and input costs. The average production cost per bag in 2010 varied from as low as ZMK 34,000 in the Eastern and Northern Provinces (representing 35% of national production) up to ZMK 53,000 in the Copperbelt and Western Provinces (10% of national production). Within-village production cost differences arise due to differences in farmer ability and knowledge and the various management decisions they make.

These sources of variation result in a wide range of production costs in Zambia, which leads to the conclusion that there is no single "cost of maize production". There is only a distribution of production costs across the millions of maize farmers in Zambia. This analysis reports the range of production costs for all maize farmers surveyed in the 2010 Crop Forecast Survey. The most productive 20% of farmers in the 2010 CFS produced maize at a mean of ZMK 15,567 per bag. The next most productive 20% of farmers produced maize at ZMK 29,078 per bag. Mean production costs for the third and fourth quintiles of production costs were ZMK 42,776 and ZMK 64,341 per bag, respectively. The least productive maize farmers' production costs were well over ZMK 100,000 per bag, which in many cases likely reflected unexpected events leading to partial or near total crop losses. In such cases, production expenses are extremely high when

expressed relative to bags produced. The wide variations in production costs per bag are due to variations in farmers' production costs per unit of land planted, but especially due to variations in farmers' yields.

The second key observation from the analysis of 2010 production costs is that 86% (2.06 million MT) of Zambia's total maize output was produced at a total cost lower than the ZMK 65,000 FRA buying price. The mean cost of production per bag was ZMK 40,739. Cash expenditure on inputs per bag was ZMK 18,630 on average.

Thirdly, the majority of Zambian maize could be sold at a profit competitively in regional markets. At the beginning of the 2010 harvest season, the export parity price (the landed cost of maize in Lubumbashi, Democratic Republic of Congo (DRC), minus transfer costs from Kabwe to Lubumbashi) was roughly ZMK 59,000. Meanwhile, 1.8 million metric tons of Zambian maize was produced at costs lower than 50,000 ZMK/bag. It was found that smallholder households selling or expecting to sell maize produced maize at somewhat lower costs than the average (roughly 38,000 ZMK/bag). Among this group, 76-82% of the maize produced could have been competitive in regional export markets.

Fourth, there is a strong correlation between higher yields and lower costs of production. This is not surprising. Clearly, a key factor in increasing Zambian maize producers' comparative advantage in the region will be the promotion of productivity enhancing technologies and agronomic practices.

Fifth, rural smallholder production remains highly labor-intensive. On average, family labor accounts for 62% of the total cost of maize production in Zambia's small- and medium-scale farm sector. Promoting the identification and adoption of practices and technologies that save labor and /or identifying labor-productivity-enhancing technologies through research and development will therefore help to make Zambian maize more competitive and allow farmers to maintain profitability even at lower producer prices.

Finally, we find that many productivity-enhancing technologies are in use in Zambia and in many cases, they are cost effective. We demonstrate that, rather than driving up cost of production per bag, fertilizer use is profitable under the right conditions. That said, there is also evidence of fertilizer users who do not see positive returns, indicating either poor management practices, late availability of fertilizer, and/or application in areas that contribute little to maize yields, such as under highly acidic soil conditions. Furthermore, there is evidence of several other technologies being employed in Zambia that also may enhance productivity. For example, regression analysis suggests numerous tillage methods (including plowing, ripping, zero tillage, basin planting, and ridging) show signs of raising gross margins and/or reducing production cost per bag. Herbicides, which are currently applied to roughly only 3% of maize fields, significantly contributed to higher gross margins per hectare planted, despite the additional cash investment added to production cost per hectare. Extending knowledge of tillage practices and their benefits as well as appropriate input use to smallholders may be a relatively high-return policy option.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

ACF	Agricultural Consultative Forum
AEZ	Agro-Ecological Zone
CFS	Crop Forecast Survey
CSO	Central Statistics Office
DFE	District Fixed Effects
DRC	Democratic Republic of Congo
FRA	Food Reserve Agency
FSRP	Food Security Research Project
GRZ	Government of the Republic of Zambia
ha	Hectare
MACO	Ministry of Agriculture and Cooperatives
MSU	Michigan State University
MT	Metric Tons
OLS	Ordinary Least Squares
OPVs	Open Pollinated Varieties
USAID	United States Agency for International Development
ZMK	Zambian Kwacha (currency)

1. INTRODUCTION

Despite the fact that the subject is frequently at the center of the national development and policy debates, the cost of maize production is rural Zambia is poorly understood. At the front of these debates, for example, is the price offered to farmers by the Zambian Food Reserve Agency (FRA) each year, which is set to provide an adequate return for farmers and incentives to continue producing, based partially on some estimate of the costs of production. Hence, efforts to ensure that FRA maize prices are set after consideration of maize production costs would assist government in achieving and balancing its various national policy objectives.

For example, setting high FRA producer prices far above the production costs of most farmers would encourage greater maize production and support farmer income growth among maize selling households, but it would raise the cost of maize for consumers and may impose major financial costs of the Zambian treasury, as is likely to be the case in the 2010/11 marketing season. By contrast, setting a FRA producer price at or below production costs of most producers would put downward pressure on maize prices for the benefit of consumers, and it might impose fewer costs on the treasury, but it would do little to promote the interests of maize selling farmers and could eventually lead to a substitution out of maize into other crops.

These policy debates have unfortunately never benefitted from empirical analysis of maize production costs by smallholder farmers based on nationally representative farm surveys. This lack of accurate production cost information can contribute to the types of problems experienced in the 2010/11 marketing season: the accumulation of massive FRA surpluses that cannot be sold except at a major financial cost to the Zambian treasury.

To address the lack of empirical data on costs, the 2010 CFS, conducted by the CSO and MACO, was modified to include specific questions relating to the smallholder's land, labor, and capital costs associated with producing and marketing maize. The objective of this study is to analyze these data to provide estimates of the cost of maize production of smallholder farmers in Zambia as well as to identify the factors causing these estimates to vary across the surveyed households. The results of this analysis will provide policy makers with information to guide FRA price setting as well as information to evaluate the competitiveness of Zambian maize production in regional markets, and identify potential alternative policy options to promote productivity.

2. DATA AND METHODS

This study uses data collected as part of the CSO/MACO 2010 CFS. The survey collected household- and field-level data on input use and production from 11,201 maize growing smallholder households, of which 11,040 harvested maize. The CFS regularly collects data on costs such as fertilizer, herbicide, seed and land use, transport of inputs to the field and transport of maize to the market. The 2010 survey also included a comprehensive set of questions regarding the quantity of hired and family owned animals and tractors used, as well as the number of individuals, days and hours of hired and family labor that were employed to accomplish the activities related to maize production.[1]

These data present three possible ways to compute the cost of production. First, we will compute cash expenditures for inputs such as hired animals or laborers, fertilizer, seed, herbicides, and transportation of inputs and outputs. This can be used to measure returns to household inputs (such as labor, land and other assets) at a given unit and selling price. Secondly, after assigning some value to household labor, and animal and tractor use, we will compute these household costs in addition to cash expenditures. We will then assign a value to the land under cultivation and compute the total cost of production at the household level. These calculations will then be used to estimate the production costs of Zambian smallholders and the extent of variability across farms. Finally, regression analysis will identify community, farm management, and household characteristics associated with relatively lower unit cost of production.

Data for the cost of hired labor and traction equipment was collected at the field level. Household-owned animals, equipment, and household labor are valued at opportunity cost rates (that is rates that could be obtained in alternative employment if they were not employed at home, and if such employment were available). Specifically, based on information gathered from households that did hire these inputs, we establish a local market rate for equipment and labor, and assign these values to the use of household assets. For animal and machine equipment, this is accomplished by computing the local[2] median cost of employing such a resource per hectare for each activity. Similarly, for labor we find the local median hourly wage for each activity and assign that to the amount of time household labor is employed. Contributions from household members are also weighted according to the adult equivalents of the members working, based on their age and gender.[3] This is to account for the fact that one would not expect the labor contribution of, for example, a 12 year old boy or girl to be the same as that of a 30 year old man or woman. The median of hourly wages used in computation can be found in Appendix A by province and type of labor activity. These generally range from ZMK 400 to 3,000 per adult per hour for various activities. Appendix A also includes some sensitivity analysis on the valuation of labor and fertilizer costs.

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[1] These activities include land preparation, planting, basal and top dressing fertilizer application, up to three weedings, harvesting, transportation from the field to the homestead, and the shelling and packing of grain.
[2] This median is taken at the most localized level that has at least five observations, usually within the same Standard Enumeration Area.
[3] Based on the World Bank figures on consumption adult equivalents, these equivalents are for men over 12 years (1.0), women over 12 years (0.805), boys 12 and younger (0.842), and girls 12 and younger (0.732). Obviously consumption based equivalents are not optimal, but this is the best approximation known to the authors barring further research on production adult equivalents.

Unfortunately, these data were collected well after labor was actually employed, in some cases several months after the activity was carried out, which presents several challenges. Particularly, a preliminary examination of the data suggests some households may be overestimating the amount of household labor employed. For example, several households reported that many more men or women from the household worked in the field than were reported as household residents in response to demographic questions. In some cases, potential overestimates were revised to the extent that they could be verified using other data collected (e.g. if the household only has 6 resident adult men during the past agricultural season, claims of more than 6 household men working on, say, land preparation were revised down to 6). In other cases, data were cleaned based on the authors' first hand knowledge of reasonable responses at the village level. For example, a response that more than 24 hours had been worked by each person in a given day would be recoded as 10 hours. For such cases, the percentage of observations that were revised is less than 0.1%. A full table of each maximum value by variable can be found in Appendix B.

Given that the hourly wage assigned to family labor is likely to be well above the economic cost of that labor, and the fact that preliminary examination of the data suggests households may be overestimating the amount of family labor spent on a given activity, we consider the method outlined above to produce an upper-bound limit of the actual cost of production. Finally, these costs are combined with total harvest data to compute the cost of producing a 50 kg bag of maize for each household in the sample so that our unit of analysis can be compared to relevant buying prices. We will also present the return to each household labor-day and the gross margin per hectare of land.

Preliminary observation of these calculations revealed a number of outlier households that produce relatively little maize, but where, despite the cleaning process described above, cost of production for a 50 kg bag was computed as several hundred thousand Kwacha, with the bulk of that cost coming from the valuation of family labor. To avoid allowing these observations to affect the results of this study unduly, our analysis will only include those households whose total costs, including unpaid family labor, asset use and land value, are ZMK 200,000 or less. While this admittedly excludes the very highest cost producers from our analysis, it is worth noting that excluding these households results in the exclusion of only 2.2% of total maize produced in the 2010 harvest.

3. RESULTS

The results in this study report the distribution of production costs across the national sample of farm households and the geographic variance in costs. We discuss the correlation between yield and costs, and the role of labor in production costs, gross margins on land use, and returns to labor and management devoted to maize production. Finally, we employ regression analysis to identify the community, farm management, and household characteristics associated with lower unit-production costs and higher margins in Zambian smallholder farmer maize production.

3.1. Maize Production Costs on Smallholder Farms

The cost buildup of Zambian smallholder production per 50 kg bag of maize is summarized in Table 1. In this table the first five columns represent the mean cost of production from various sources by total cost quintiles at the household-level. The sixth column is the household-level mean cost from each source at the national level. Obviously, different households produce different amounts of maize, which will not be reflected in household mean costs.

Table 1. Maize Production Costs (ZMK/50kg bag) by Quintile

	Total Cost Quintile (ZMK/50 maize kg)						
	1	2	3	4	5	farmer mean	per 50 kg bag mean
Share of total maize production (%)	31.4%	27.1%	20.1%	12.8%	8.7%		
Costs of production (ZMK/50kg)	----------Mean----------						
Hired animal use	283	516	829	1,163	1,763	911	536
Hired machine/tractor use	22	57	49	153	103	77	97
Hired labor	1,493	2,662	3,340	4,825	6,619	3,788	3,438
Basal dressing [a]	1,314	2,479	2,897	3,549	4,419	2,932	3,487
Top dressing [a]	1,290	2,585	2,964	3,863	4,627	3,066	3,576
Fertilizer transport to homestead	39	108	143	184	223	139	193
Transport cost to FRA depot	349	606	407	296	208	373	763
Transport cost to private buyer	189	365	543	544	997	528	2,044
Herbicides	15	24	63	17	46	33	62
Seeds [a]	1,417	2,838	3,734	4,853	8,478	4,265	4,434
Total cash expenditures	6,411	12,239	14,969	19,449	27,482	16,111	18,630
Family labor	8,274	15,379	25,585	41,810	87,103	35,638	19,745
Own animal use	873	1,431	2,179	3,071	4,287	2,368	2,304
Own machine use	9	29	43	12	82	35	61
Expenditures plus household labor and assets (excl. land)	15,567	29,078	42,776	64,341	118,953	54,152	40,739
Land annual rental	3,364	4,835	6,633	9,152	15,102	7,818	4,720
Total Cost (incl. land cost)	18,931	33,914	49,409	73,493	134,055	61,970	45,459

Source: MACO/CSO Crop Forecast Survey 2010.
Note: a) Fertilizer and seed costs include both subsidized and commercially acquired inputs.

Therefore, the far right column in Table 1 presents the production-weighted average cost of each activity involved in producing maize. This column can be thought of as the average cost of producing a 50 kg bag of maize in Zambia in the 2009/10 crop season. The first row of results, above the cost of production breakdown, shows the share of total maize production by each quintile.

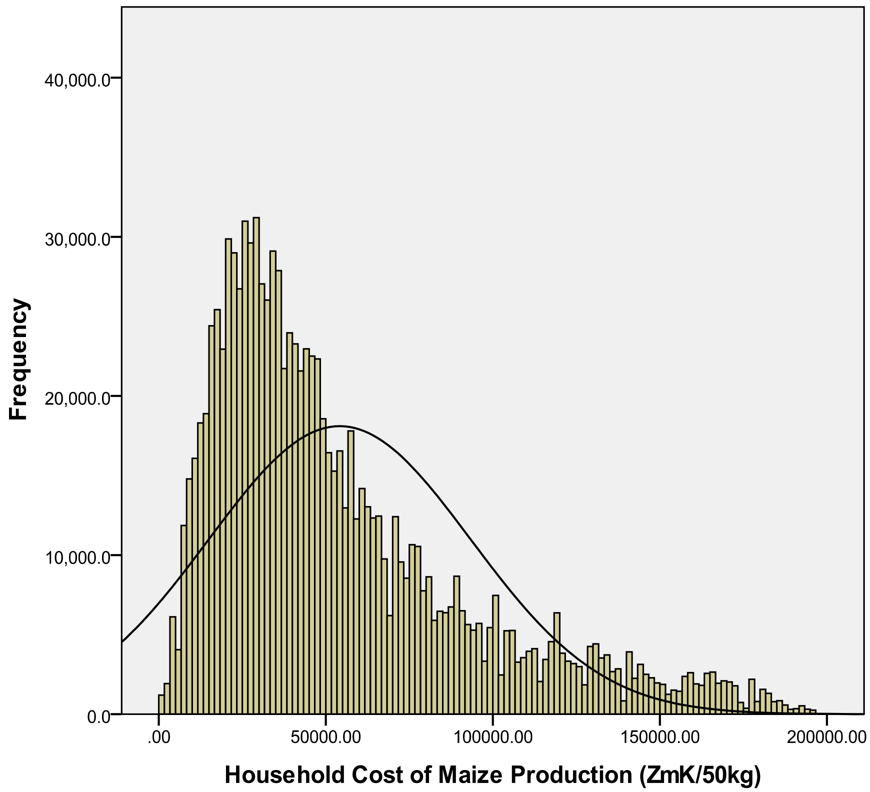
Three totals are highlighted in gray at the appropriate stage in each buildup: total cash expenditures excluding land, cash expenditures plus family labor and equipment use, and total cost including land. The computations including imputed land rental values of smallholders' own land is included for the sake of comprehensiveness in our analysis, however the second calculation (all costs excluding land) is considered most relevant in Zambia. Most Zambian farmers are considered to have the right to freely use land provided to them by traditional local authorities, but if they do not use this land, they do not have the right to sell it. They may rent their land, but in practice, only a small proportion of households rent their land even when not being fully utilized. For these reasons, the opportunity cost of most smallholders' land, if not fully utilized, is considered to be low. Moreover, policy makers seldom consider the value of land in customary areas as a cost of production. Therefore, for the remainder of this study the unqualified phrases *cost* or *cost of production* refer to the calculations that do not include the rental value of their land. Calculations that do include the rental value of land will be referred to as *total cost of production*.

The first thing to notice in Table 1 is that the more efficient farmers produced a greater share of national maize production than their high cost counterparts did. The most efficient 20% of farmers, for example, produced 31.4% of national output. The 20% of farmers in the highest total cost quintile, on the other hand, produced only 8.7% of national output. In fact, 9% of Zambian maize producing smallholder households are in both the lowest total cost quintile and the highest yield quintile. That group alone contributed 21.1% of the national production (509 thousand MT). Conversely, 10.1% of rural maize producing households are in both the highest total cost and lowest yield quintiles, and contributed a relatively small 2.6% of national output (63 thousand MT).

Moreover, we can see that cost of production for the majority of households and for the majority of maize produced is well below the FRA price for 2010. For example, the first three columns demonstrate that 78% of the maize in Zambia's 2010 harvest was produced by 60% of the farmers, in an average cost range of ZMK 15,567 to 42,776 per bag.

The average cost of production per household is nearly ZMK 54,000 per bag. However, the distribution of household production costs is highly skewed. Figure 1 is a histogram of households by their costs of production, with a "normal" distribution curve for this sample's mean and variance superimposed. In this figure, it is clear that a much larger share of households produce at a cost below the farmer-mean cost (the peak in the normal curve) than those who produce above it.

Figure 1. Distribution of Households by Cost of Production



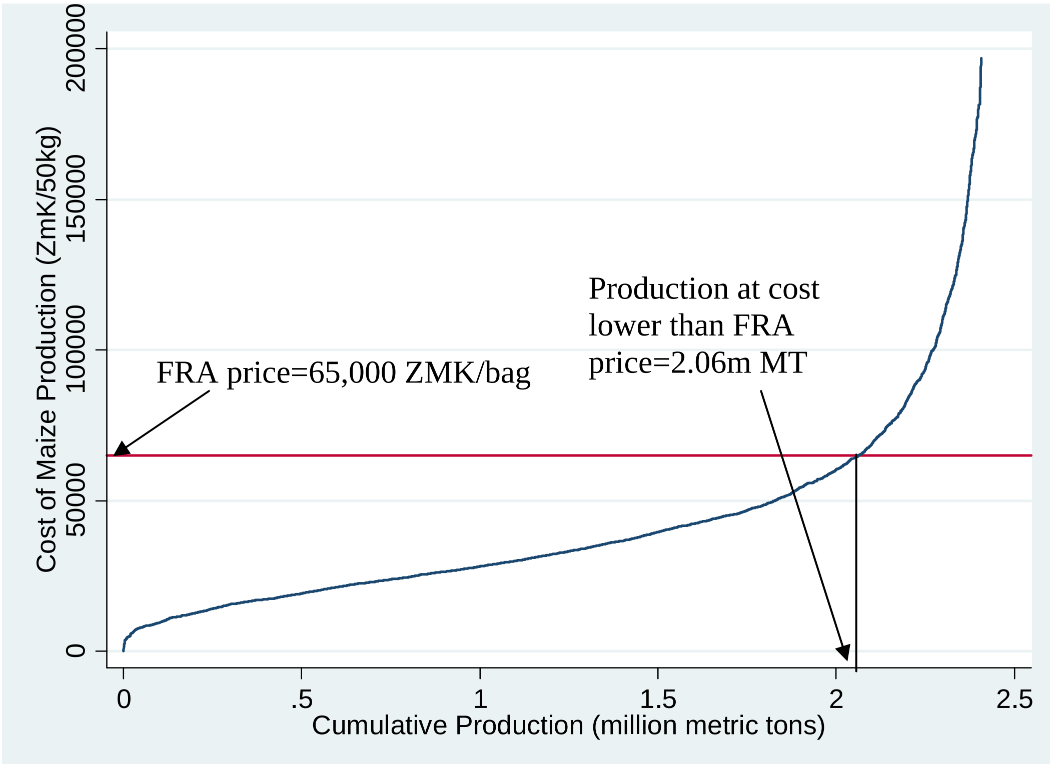
Source: CSO/MACO Crop Forecast Survey 2010

Moreover, after accounting for the fact that lower-cost producers are producing more maize, the national figure for total production costs is below the mean household level, as shown in the far right column of Table 1. At the national level, the average production cost for a 50 kg bag of maize is ZMK 40,739. For producers growing maize at this mean production cost and selling to FRA, the profit on each bag sold is about ZMK 24,000 beyond production costs including family labor, animal or tractor use and all cash input costs. This constitutes a 60% markup over costs, i.e., net revenue per bag produced is 60% greater than production costs per bag.

Furthermore, as the first row in Table 1 indicates, the lowest cost producers grow the most maize per household, and are thus more likely to be those selling to FRA. Therefore, the actual profit margin for households selling to FRA is likely to be even higher. Indeed, among the households that sold exclusively to the FRA in 2009, average cost of production per bag in 2010 was ZMK 35,767. Production costs for those expecting to sell in 2010 were ZMK 38,278, which would have been sold to FRA at a 70% markup.[4]

[4] Full tables of the cash expenditures, costs, and total costs of production by 2009 market participation status and expected 2010 market position can be found in Appendix D. Table D1 presents the household means per group. Table D2 presents the production weighted or "per bag" averages.

Figure 2. Cumulative Distribution of Production Cost vis-à-vis FRA Price



Source: CSO/MACO Crop Forecast Survey 2010

Figure 2 presents the cumulative distribution of maize production against the cost of production, and presents the graph in the context of the 2010 FRA buying price, which is shown as a straight reference line. Once again, the majority of all maize production is done at a cost below 65,000 ZMK/bag. Specifically, 2.06 million metric tons (more than 80% of total smallholder production) was produced at a total cost lower than the FRA price.

Another very important observation from Figure 2 is that it appears a large share of total output in 2010 was produced at a cost that would have been competitive on regional markets. A report from the Agricultural Consultative Forum (ACF) and FSRP, published online in April 2010 (harvest time for the period covered by this study) reckons the export parity price for maize is approximately ZMK 59,000 per bag,[5] Figure 2 demonstrates that more than 1.8 million metric tons were produced in Zambia at a cost below ZMK 50,000. Moreover, 82% of the maize that was grown by households who were expecting to sell had a cost of production lower than ZMK 59,000 and 76% was produced at costs below ZMK 50,000.

[5] Obviously, parity prices will change depending on the trading partner, prevailing world prices and so on. This figure is based on that report's calculation of an export parity price of $253 per metric ton (point 13) and a 4700:1 exchange rate.

3.2. Geographic Variance in Cost of Production

To evaluate the geographic variance in production costs production weighted means of the three measurements for costs from Table 1 are examined at the provincial and agro-ecological zone (AEZ) level in Table 2, along with each region's contribution to total production. AEZ's are listed with their suitability level as reported by the Government of Zambia (GRZ 2007).[6]

First note the wide range in cash expenditures (fertilizer, purchased seed, etc) at the provincial level. Cash expenditures vary from 12,654 ZMK/bag in the Western Province to a high of 26,099 ZMK/bag in the Copperbelt Province. Interestingly, Western Province is also where we find the highest total cost (63,688 ZMK/bag). High production costs in Western Province are due to higher family labor input than in all other provinces, which implies a labor-intensive and capital-saving approach to maize production. Many areas of Western Province have poor soils that are not suitable to intensive maize production. For these reasons, Western Province exhibits the highest production costs of all provinces.

Table 2. Cost of Production and Share of Total Production by Province and AEZ

Province	Share of Total Production	Total Cash Expenditures	Expenditures plus household labor and assets (exl. land)	Total Cost of Production
		---------------------ZMK per 50 kg bag	------------------------	
Central	0.21	23,237	43,958	47,785
Copperbelt	0.07	26,099	53,143	58,500
Eastern	0.22	13,925	34,096	38,569
Luapula	0.03	16,203	38,531	41,374
Lusaka	0.04	22,174	44,279	50,470
Northern	0.13	20,370	34,197	37,615
North Western	0.05	17,833	42,801	48,166
Southern	0.22	16,243	41,320	46,630
Western	0.03	12,654	53,018	63,688
All Zambia	1.00	18,630	40,739	45,459
Agro-ecological Zone				
I -Marginally Suitable	0.06	17,145	51,128	59,454
IIa -Suitable	0.64	17,893	39,305	43,682
IIb -Marginally Suitable	0.02	14,835	47,279	57,702
III -Moderately Suitable	0.28	20,956	41,129	45,357
All Zambia	1.00	18,630	40,739	45,459

Source: CSO/MACO Crop Forecast Survey 2010

[6] See the full map of crop suitability by AEZ in Appendix C

The lowest total cost of production, on the other hand, is found in the Northern Province, where the average 50kg bag of maize in 2010 was produced for ZMK 37,615. Northern Province has the highest ratio of cash expenditure to total costs, which indicates high use rates of cash inputs, and therefore relatively capital intensive and labor-saving production practices. At least in 2010, the results indicate that relatively capital-intensive, labor-saving production approaches obtained the lowest costs of maize production on smallholder farms.

Table 2 also demonstrates that 92% of total maize production comes from the two agro-ecological zones deemed to be *suitable* or *moderately suitable* for maize Production, i.e., Zone IIb and III. Average cost per bag was about ZMK 40,000 in these two zones. The marginally suitable zones, on the other hand, produce only 8% of national production at an average cost much higher than the national mean.

The geographic variance in production costs across provinces and zones highlight again that there is no single *cost of production*, but rather a wide distribution that will in part depend on agro-ecological suitability for maize production.

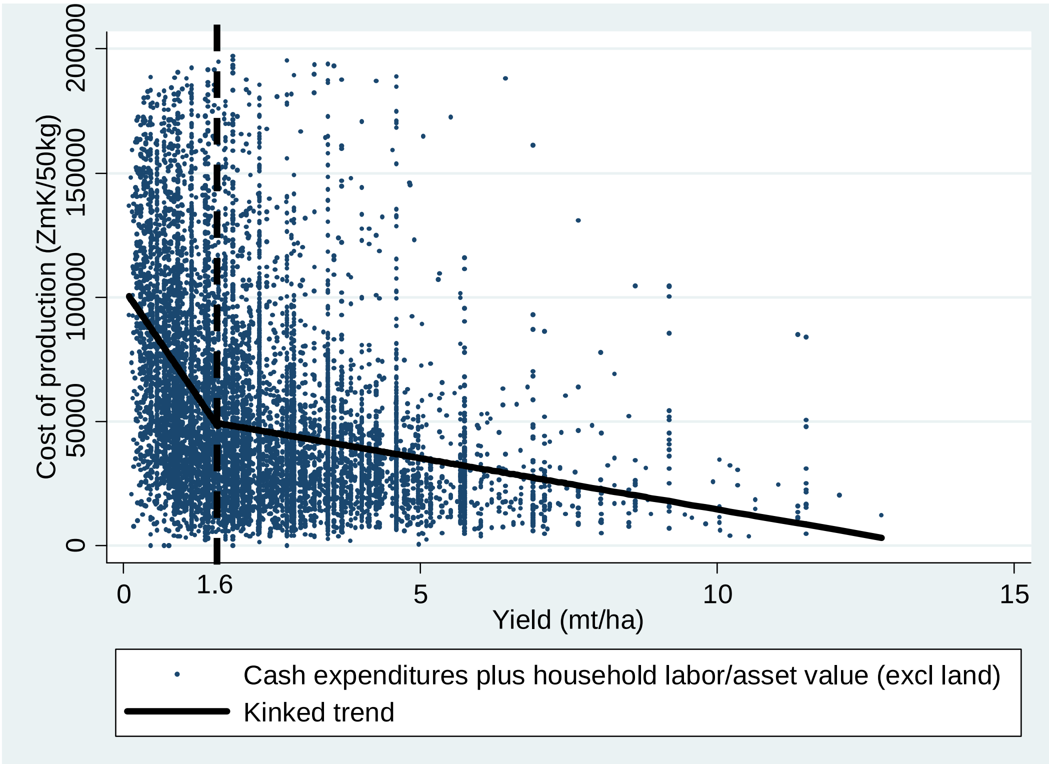
3.3. Yield and Cost of Production

The correlation between the ecological suitability for maize production and low production costs suggests that yield is an important factor in determining unit costs. This is examined in Figure 3, which shows each observation in our sample on a two-way scatter plot of production cost on the vertical axis and yield on the horizontal axis. The graph also includes a line representing the fitted values of a trend line, which is kinked at about 1.6 metric tons per hectare (MT/ha).[7]

The fitted trend predicts a very steep decline in unit production costs as very low level yields begin to increase. Beyond 1.6 MT/ha, yield increases continue to be correlated with decreasing production costs, though at a slower rate. This kink is consistent with the hypothesis that raising very low yields is more a function of improved farming technique or relatively beneficial ecological conditions (i.e. very low or no cost interventions and differences). Beyond some point, however, yield improvements will inevitably require more sophisticated interventions such as fertilizer, improved seed, or herbicide use. While such practices seem to increase the profitability of each bag harvested, the increases will inevitably occur at a slower rate due to the financial investments required to continue driving up yields.

[7] This trend is optimal as compared to the linear trend, quadratic trend, and all other possible kinked trends. The Chow test shows this trend is a significantly better fit to the data than the linear trend at the 0.1% confidence level.

Figure 3. Scatter Plot and Trend of Household Production Costs over Yield



Source: CSO/MACO Crop Forecast Survey 2010

3.4. Labor and Cost of Production

Thus far, we have focused primarily on the aggregate cost of production figures. If taken alone these figures mask the fact that the largest source of cost is family labor. The average family labor value's share of total cost of production is 62%, and this share tends to increase as total cost increases.[8] As indicated in the methods section, recall that family labor is valued at the agricultural wage rates prevailing in local area.

Table 3 examines how this labor is being employed by each of the 10 major production activities, and the distribution of family hours spent on each across households. The activities requiring the most labor on average are land preparation, the first weeding, harvesting and shelling and packing. Once again, however, we see that the distribution of family labor input varies substantially, and is highly skewed. To illustrate this point, note that each 50th percentile value is lower than the national mean, indicating that for each production activity more than half of all households use less than the average amount of family labor hours.

Table 3 also shows that a sizable share of the population employs far more than the average amount of family labor for various activities. For example, while less than half of the population requires more than 90 hours of family labor to prepare a hectare of land, 25% of the population

[8] The coefficient of correlation between family labor ratio and total cost per bag is 0.19, and is statistically significant at the 0.01% level

Table 3. Distribution of Adult Equivalent Family Labor Hours per Activity per Hectare

	Percentile					
	10	25	50	75	90	Mean
Production Activity	-------------------Family labor hours-------------------					
Land preparation	0	11	90	301	650	247
Planting	10	24	52	103	219	94
Basal dressing application	0	0	0	32	79	28
Top dressing application	0	0	0	32	80	30
First weeding	0	47	143	298	531	231
Second weeding	0	0	0	103	277	93
Third weeding	0	0	0	0	0	17
Harvesting	10	42	102	203	375	167
Transport (field to homestead)	0	13	46	124	260	106
Shelling and Packing	0	31	91	216	417	175

Source: CSO/MACO Crop Forecast Survey 2010

reports using more than 300 family hours in the field, and 10% report more than twice that amount. A similar story holds true for the other major sources of labor demand.

Unsurprisingly, the wide distribution in labor hours assigned to each task leads to a correspondingly wide distribution in returns on family labor. Table 4 presents the distribution of household returns to labor days and the cost build-up (excluding family labor) per hectare of land for each group. Gross revenue is presented in this table, assuming the FRA buying price of ZMK 65,000 per bag (ZMK 1,300 per kg). The bottom row of this table displays the average return on a family labor day for each quintile of the distribution.[9]

The lowest return to labor quintile has a negative return on each labor day on average, despite the fact that average net revenue per hectare (excluding the cost of household labor) is positive for that group. This implies that the lowest net revenue households use the least amount of family labor within this quintile. Households in the highest quintile, on the other hand, earn ZMK 70,146 return on a day's labor on average. At the national level, the average household earns a return of ZMK 18,844 per day devoted to maize production if selling at the FRA price of 65,000 ZMK/bag.

Interestingly, in terms of cost buildup, the highest and lowest return to labor quintiles are similar, and generally spend more on inputs than the other 60% of the population. In fact, the lowest return to labor quintile spends more per hectare on fertilizer and seed combined than the highest return quintile. The difference is that among the highest return quintile yields are much higher (3.6 MT/ha compared to 1.3 MT/ha) and production is much less household-labor intensive (using 79 labor days per hectare versus 394).

[9] A labor day is considered to be 5 hours, which is the sample mean and median for number of hours per day spent on a labor activity

Table 4. Returns to Labor Days per Hectare Planted

	Returns to labor quintiles					
Revenue	1	2	3	4	5	Mean
Yield (kg/ha planted)	1,282	1,720	2,112	2,618	3,573	2,261
Price (ZMK/kg)	1,300	1,300	1,300	1,300	1,300	1,300
Gross Revenue (ZMK/ha)	1,666,998	2,235,686	2,746,225	3,403,496	4,645,496	2,939,637
Costs (ZMK/ha)						
Hired animal use	111,541	70,919	81,838	89,496	96,437	90,045
Hired machine use	7,434	1,986	3,014	3,129	7,656	4,644
Hired labor	211,777	81,440	92,753	124,204	201,691	142,370
Basal	172,725	94,266	121,997	141,511	191,926	144,483
Top dressing	174,741	106,863	124,130	145,070	190,268	148,213
Fertilizer transport	9,706	4,218	5,148	6,285	8,935	6,858
Transport to FRA	13,584	12,301	18,940	32,758	47,669	25,051
Transport to other buyer	52,898	11,288	17,975	24,216	44,194	30,113
Herbicides	1,570	346	1,720	1,226	3,059	1,584
Seed	262,520	123,309	147,688	161,964	199,423	178,977
Own animal use	76,710	50,061	56,232	61,976	68,726	62,740
Own machine use	1,742	204	1,659	715	2,764	1,417
Costs excl' land/hh labor	1,096,947	557,199	673,093	792,549	1,062,748	836,494
Net revenue (ZMK/ha)	570,051	1,678,487	2,073,132	2,610,947	3,582,748	2,103,143
HH labor days (days/ha)	394	348	229	156	79	241
Return to labor & land (ZMK/day)	-875	4,966	9,216	17,206	75,560	21,217
Land cost (ZMK/ha/year)	221,908	218,356	215,410	211,929	203,514	214,223
Costs excl' hh labor	1,318,854	775,555	888,503	1,004,479	1,266,262	1,050,717
Net Revenue (ZMK/ha)	348,143	1,460,131	1,857,722	2,399,018	3,379,234	1,888,920
Return to labor (ZMK/ day)	-2,666	3,850	7,683	15,198	70,146	18,844

Source: MACO/CSO Crop Forecast Survey 2010.

All together, these results indicate that high-cost maize producers tend to devote large amounts of labor time to their maize plots but get relatively low yields. There may be several explanations for the high labor input - low yield outcomes, including adverse weather events such as flooding or pest damage, as well as low levels of management expertise, and in some cases poor soils.

3.5. Gross Margin Analysis

Table 5 presents the gross margins (ZMK per hectare of land) for Zambian maize production. Gross margins are defined as the revenue per hectare planted to maize minus the costs incurred on that hectare over the growing season. Table 5 shows how gross margins vary across households and presents the national mean in the final column. Once again, we value maize output at the FRA buying price to compute gross revenue, followed by the cost buildup for each group presented in rows. As gross margins are measured per hectare of land, the cost of land is not considered here. The gross margin, therefore, could also be considered the returns to land.

As with cost of production, gross margins vary greatly across smallholder farms in Zambia. First, note that the bottom quintile of the distribution has negative gross margins per hectare on average, while at the national level the mean margin is ZMK 1,108,542 per hectare. As with total cost this distribution is highly skewed, and the top quintile of producers would enjoy a gross margin greater than ZMK 4 million per hectare planted if selling at the FRA price.

Here too, the driving forces behind the difference between the lowest and highest quintiles seem to be the intensity of household labor use and input productivity. The cost of family labor among the lowest gross margin quintile is above ZMK 2.5 million per hectare, compared to ZMK 776,116 for the highest quintile. Meanwhile, yields for the 20% of households with the lowest gross margins are less than 1.7 MT/ha on average compared to more than 4.4 MT/ha on average for the highest gross margin quintile. In other words, the most profitable maize producers devoted relatively low family labor and achieved high yields, while the least profitable farmers devoted high amounts of family labor but obtained low yields.

Table 5. Gross Margins for Zambian Maize Production (ZMK/ha)

	Gross margin quintiles					Farmer
	1	2	3	4	5	mean
Yield (kg/ha planted)	1,607	1,179	1,675	2,493	4,421	2,275
Price (ZMK/kg)	1,300	1,300	1,300	1,300	1,300	1,300
Gross Revenue (ZMK/ha)	2,088,454	1,532,097	2,177,930	3,241,058	5,746,974	2,957,341
Costs (ZMK/ha)						
Hired animal use	107,787	97,186	88,822	79,808	73,801	89,482
Hired machine use	6,705	3,107	3,100	3,402	7,246	4,712
Hired labor	200,150	117,093	100,705	156,141	198,715	154,568
Basal	172,599	86,033	92,777	150,319	233,677	147,088
Top dressing	180,470	92,968	97,821	156,085	225,662	150,608
Fertilizer transport	9,579	4,277	4,080	7,479	9,545	6,993
Transport to FRA	13,349	6,934	13,949	28,454	67,175	25,973
Transport to other buyer	56,652	13,882	17,570	28,969	36,507	30,719
Herbicides	1,523	579	1,606	1,559	2,996	1,653
Seed	275,545	117,949	117,387	166,048	230,332	181,466
Family labor	2,559,361	949,405	930,752	815,579	776,116	1,206,384
Own animal use	74,089	70,904	59,362	56,068	50,354	62,156
Own machine use	1,774	450	1,755	777	2,346	1,421
Total costs excl' land	3,436,075	1,351,404	1,312,816	1,444,282	1,698,510	1,848,799
Gross margins (ZMK/ha)	-1,347,620	180,692	865,113	1,796,776	4,048,464	1,108,542

Source: MACO/CSO Crop Forecast Survey 2010.

A second finding from Table 5 is that the level of fertilizer application is greatest in the top (most profitable) and bottom (least profitable) quintile of gross margins. On average, the lowest gross margin quintile households spend more on fertilizer and seeds than the national mean. Households in the highest gross margin quintile also spend more on fertilizer and seeds than the national mean. This finding means that fertilizer application may contribute to high gross margins under appropriate soil, rainfall, and farmer management conditions. However, high fertilizer use does not assure improved profitability of maize production. Smallholder farmers' maize production can become more profitable by providing the crop husbandry extension assistance, timely availability of fertilizer, and other synergistic inputs to raise the contribution of fertilizer use to yields. This will of course also contribute to the competitiveness of Zambian farmers in regional markets.

The farms achieving relatively high yields and gross margins despite low labor input as shown in Table 5 are likely to (i) be located in the more productive areas of the country, which (ii) experience greater returns to fertilizer and hybrid seed application, and (iii) employ good farm management practices.

These results have two important implications for the promotion of productivity enhancing technologies. First, technology must be appropriate for the farmer and their field. Fertilizer application may greatly raise gross margins and the returns to labor in favorable areas. By contrast, fertilizer application may reduce gross margins and the returns to labor in agro-ecologically unsuitable or risky production areas. It may be, for example, that fertilizer application may do little to raise yields in the presence of pre-existing soil acidity. Secondly, input adoption must be followed by the knowledge on how to use it appropriately. For example, high seed costs and low returns to land may be due to late planting, inappropriate spacing between plants, row spacing, and/or inappropriate use of fertilizer.

Table 6 reports gross margins by province, valuing maize at the 2010 FRA price of ZMK 65,000 per 50 Kg bag. These results closely mimic the provincial estimates of production costs. Northern Province, which has the lowest production costs, consequently enjoys the greatest gross margins in maize production. By contrast, Western and Copperbelt, which have relatively high production costs, have the lowest gross margins. On average, a hectare of maize planted in 2010 provided a mean gross margin of 1,178,635 ZMK in profit, after deducting the costs of all cash inputs and labor.

3.6. Regression Analysis

The above analysis demonstrates that there is a wide range of production costs, returns to labor, gross margins, and net revenue per farm in Zambian maize production. The question remains, however, as to what accounts for this wide distribution. To address that question we move to regression analysis to determine what community, farm management, and household characteristics are correlated with lower costs of production and higher gross margins.

Table 6. Gross Margins for Maize Production by Province, 2010

Province	Total Returns on Land (ZMK)	Hectares planted (ha)	Gross Margin (ZMK/ha)
Central	234,101,168,934	187,019	1,251,751
Copperbelt	57,323,553,287	77,462	740,019
Eastern	348,665,010,318	284,183	1,226,903
Luapula	38,641,934,340	27,943	1,382,862
Lusaka	43,284,534,930	32,028	1,351,447
Northern	207,616,920,992	111,132	1,868,199
North Western	69,226,360,074	61,420	1,127,096
Southern	253,221,500,717	243,944	1,038,032
Western	29,897,675,405	62,549	477,989
All Zambia	1,281,978,658,997	1,087,681	1,178,635

Source: MACO/CSO Crop Forecast Survey, 2010.

Table 7 presents results from four ordinary least squares (OLS) regressions. Columns 1 and 2 are models for the total cost (cash expenditures and the use of household labor and assets, excluding land) of producing a 50 kg bag and the gross margins per hectare of land respectively. These models control for geographical determinants using agro-ecological dummy variables and rainfall data on the total accumulation and the number of stress periods during the growing season (November to March). The latter is measured as the number of back-to-back-10 day periods with less than 40 mm of rainfall. In columns 3 and 4 the dependant variables are the same, but geographical effects are controlled for using district dummy variables (not shown). We use these alternative model specifications to assess the robustness of our findings with those in columns 1 and 2.

Since management variables are field specific, regression analysis will be conducted at the field level. Note, however, that 82% of households in our sample have only one maize field (95% have one or two). Therefore, this is essentially synonymous with a household level analysis. Also, regression analysis will only use the mono-cropped fields to avoid measurement error, since gross margins and cost calculations do not account for the value of the other crops produced in the field. Note, however, that 94% of the maize fields in Zambia are mono-cropped, suggesting this measurement error is likely to be minimal in the aggregate statistics throughout section 3.

Management variables included control for the tillage method, whether tillage was done before the rains, whether improved seeds were used (either hybrid or open pollinated varieties (OPVs)), whether herbicides were used and whether the field was weeded once, twice or three times. The model also includes the fertilizer application rate in kgs per hectare, but we treat fertilizer that was available on time and fertilizer that was available late as separate variables. The quantity of basal and topdressing applied on the field are combined into one variable to circumvent collinearity problems as these applications are very highly and significantly correlated.

Household characteristics include the overall area cultivated by the household for all crops, the number of adult equivalents and the highest level of education among the household members.

The results in Table 7 highlight seven main findings.

The first set of findings focus on the yield and net income benefits of certain agronomic practices compared to the labor costs involved. Plowing, which requires less labor than hand hoeing, tends to drive down unit production costs and increase gross margins when we control for district fixed effects (DFE) in columns 3 and 4. Pre-rain tillage, which is labor intensive, significantly drives up production costs and lowers gross margins per hectare. This may help explain why less than 30% of the sample practices this method despite its agronomic benefits. The added labor costs involved appear to exceed the added revenue from adopting this practice, at least in the very good production season of 2009/10. It should be noted, however, that this conclusion is reached under the assumption that the opportunity cost of labor is the same as wage rates for labor during the rainy season. In reality, the opportunity cost of agricultural labor before the rains may be lower.

Zero tillage and basin planting, by contrast, do appear to drive down unit cost of production. This result is less significant in the DFE model. In the DFE models ridging also appears to be preferable to hand-hoeing, though the magnitude of this effect is relatively small, and gross margins on a field that used ripping tillage were more than ZMK 480,000 greater than hand hoed fields. These results provide some evidence that the major conservation farming practices do have the potential to reduce production costs and improve profitability, though the magnitude of these benefits, at least in 2010, were somewhat modest.

The second main finding is the strong geographic differences in maize production costs and profitability. Maize production costs are significantly lower in the agro-ecologically suitable areas of AEZ IIa and III. Production costs were roughly ZMK 9,600 per bag lower in AEZ IIa than in the baseline zone AEZ I, other factors held constant. Production costs in AEZ III were ZMK 8,104 per bag lower than in AEZ I, or roughly 17% lower than the national mean, holding other factors constant. Production costs in AEZ IIb (most of which is located in Western Province) are ZMK 3,842 per bag lower than in AEZ I, all else equal, but this estimate is less statistically significant. These findings are consistent with what one might expect. There are significant geographic differences in production costs and gross margins owing to differences throughout the country in agro-ecological suitability of maize production.

Third, fertilizer use, as expected, significantly increases the gross margin per hectare planted. Each additional kg applied raised gross margins by roughly ZMK 900 to 1,400 per hectare planted. This means that a 50kg bag of fertilizer tends to raise an additional ZMK 45,000 to 70,000 in net revenue over and above the costs of the fertilizer. All else equal, at the mean application rate among fertilizer users (220.19 kg/ha), gross margins are ZMK 317,688 to ZMK 199,873 greater than when no fertilizer is used for late and on-time fertilizer respectively. Note that the returns to fertilizer use were much higher than this in some areas of the country and were substantially lower than this, and potentially even negative, in other areas and for certain farmers with low management skill. Surprisingly, *late* fertilizer did not adversely affect yields in 2010, most likely because the growing season was favorable and farmers who applied fertilizer late were not penalized, as they might be if there were mid-season dry spells.

Table 7. Regression Results for Cost of Production and Gross Margins

Explanatory Variables	Dependant Variables (1) Production costs (ZMK/bag)	(2) Gross margins ('000s ZMK/ha)	(3) Production cost (ZMK/bag)	(4) Gross margins ('000s ZMK/ha)
Geographic Determinants				
AEZ III (1= yes)	-8,117***	675.2***	-	-
	(0.00)	(0.00)	-	-
AEZ IIa (1= yes)	-9,636***	514.1***	-	-
	(0.00)	(0.00)	-	-
AEZ IIb (1= yes)	-4,148**	94.16	-	-
	(0.03)	(0.37)	-	-
Rainfall (mm)	-47.91***	-0.0130	-	-
	(0.00)	(0.98)	-	-
Rainfall squared	0.0129***	0.000123	-	-
	(0.00)	(0.54)	-	-
Rain stress	-4,590***	145.4***	-	-
	(0.00)	(0.00)	-	-
District Effects	-	-	Yes	Yes
Management Practices [a]				
Planting before the rains	6,214***	-265.8***	3,196***	-127.5***
(1= yes)	(0.00)	(0.00)	(0.00)	(0.00)
Planting basins (1= yes)	-4,978*	187.9	-3,374	110.8
	(0.07)	(0.21)	(0.20)	(0.45)
Zero tillage (1= yes)	-5,901**	138.7	-2,840	-12.63
	(0.02)	(0.31)	(0.22)	(0.92)
Plowing (1= yes)	3,715***	-39.88	-3,425***	272.5***
	(0.00)	(0.46)	(0.00)	(0.00)
Ripping (1= yes)	1,420	256.5	-2,458	483.3**
	(0.68)	(0.18)	(0.48)	(0.01)
Ridging (1= yes)	353.5	96.71*	-2,089**	102.3*
	(0.73)	(0.08)	(0.05)	(0.08)
Bunding (1= yes)	-3,172	66.28	-2,943	-8.225
	(0.42)	(0.76)	(0.45)	(0.97)
Use of improved seed	3,682***	42.76	1,838**	110.6**
(incl' OPVs) (1= yes)	(0.00)	(0.34)	(0.02)	(0.01)
Late fertilizer use (kg/ha)	-3.534	1.444***	3.976	1.185***
	(0.41)	(0.00)	(0.34)	(0.00)
On time fertilizer use	-0.995	1.229***	5.464**	0.906***
(kg/ha)	(0.65)	(0.00)	(0.01)	(0.00)
Herbicides used (1= yes)	-4,460*	368.6***	-4,732*	380.5***
	(0.06)	(0.00)	(0.05)	(0.01)
First weeding (1= yes)	3,150	-28.37	3,931**	-102.3
	(0.12)	(0.80)	(0.04)	(0.34)

Table 7. (continued) Regression Results

Second weeding (1= yes)	-755.5	59.90	2,641***	-69.54*
	(0.32)	(0.15)	(0.00)	(0.09)
Third weeding (1= yes)	2,560**	-57.94	4,042***	-178.0**
	(0.04)	(0.41)	(0.00)	(0.01)
Household Characteristics				
Total area cultivated for all crops (ha)	-2,542***	122.4***	-2,094***	102.0***
	(0.00)	(0.00)	(0.00)	(0.00)
Adult equivalents	2,698***	-118.9***	2,759***	-123.2***
	(0.00)	(0.00)	(0.00)	(0.00)
Highest education among members (years)	-160.3	27.88***	-192.5*	28.75***
	(0.16)	(0.00)	(0.08)	(0.00)
Constant	82,625***	330.2	33,82***	1,060***
	(0.00)	(0.46)	(0.00)	(0.00)
Observations	11271	11271	11271	11271
R-squared	0.061	0.060	0.184	0.149

Source: MACO/CSO Crop Forecast Survey, 2010.
Note: a) Effects of mono-cropping, planting after rains, hand hoe tillage, and non-use of fertilizer, herbicides, improved seeds and weeding are all subsumed into the constant term.

The fourth main finding regards the economics of weeding. Results suggest that weeding does not appear to be an economically advantageous activity under most smallholder conditions in 2010, with a positive and significant effect in all of the cost per bag models and negative effect on gross margins in the DFE model. This should be interpreted carefully, however, as there may be an endogeneity problem here; only fields that need weeding would be weeded. Therefore, this variable may be an indicator of fields struggling with weed issues, which is the true effect being measured.

The fifth main finding regards herbicide application. Although only 3% of fields had herbicides applied, regression results suggest the benefits of its use are quite high. All else equal, applying herbicides increases gross margin between ZMK 363,700 to ZMK 376,300 per hectare planted, with each result significant at the 1% level. The magnitude of this effect is fairly large compared to the national average margin of ZMK 1,108,542 (in other words, at the mean, herbicide use would increase gross margins by roughly a third). It is possible that the profitability of herbicides in the very favorable growing season of 2009/10 may exceed that of most seasons in which the yield advantages of herbicide application may be less dramatic. Nevertheless, these results indicate that public policy measure should be considered to educate farmers about the benefits of herbicide application, as its contribution to smallholder income growth and regional competitiveness may be comparable to and highly synergistic with increased fertilizer use.

Sixth, a few other findings from Table 7 show the association between production costs, gross margins, and household characteristics. Households with more highly educated members do have significantly higher gross margins from maize production than other households. Each additional year of education adds roughly ZMK 28,000 in net returns per hectare of maize planted. For a household with 5 to 10 years more education than a neighboring household, this is a major difference in net income (ZMK 140,000 to 280,000) from cultivating a hectare of maize. Apparently, higher formal education translates into better management practices, which is consistent with expectation. The results in Table 7 also indicate that higher levels of adult equivalents significantly drive up the cost of producing a bag of maize, and drives down gross margins. This result may reflect that in larger households more people are working than need be (i.e. labor costs are artificially inflated because there is a surplus of labor in the fields). The results also indicate that larger areas cultivated are less profitable per bag and per hectare. This could be an indicator that yields tend to be higher on smaller plots.

Seventh, and finally, we obtain counterintuitive results on several variables. The coefficient on the rainfall stress variable suggests that prolonged dry periods do not necessarily raise production costs. The coefficient on improved seed suggests that the yield increasing benefits of hybrids and improved OPVs are offset by the relative price of using such seed varieties. This finding is somewhat surprising, since the agronomic benefit of improved seed use is unquestioned. On the other hand, when we control for district fixed effects, improved seed use significantly increases gross margins. Therefore, there is some evidence, albeit mixed, that improved maize seed varieties raise the profitability of smallholder maize production, though this effect was not as strong as we would have anticipated.

4. SUMMARY AND IMPLICATIONS

The objective of this study was to estimate the cost of maize production in rural Zambia as well as to identify the factors causing these estimates to vary across households. This will inform current policy discussions and potentially identify unused policy levers that could increase Zambian smallholder farmer's competitiveness in the future. Although this subject is perennially the subject of important policy debates such as determining the FRA's buying price each year, data has only recently been available to empirically inform this discussion. One of the key lessons emerging from this analysis is that good data collection on this subject will continue to be important challenge in future agricultural surveys.

Our first key observation is that the FRA pan-territorial pricing policy does not reflect the wide geographic differences in costs and even among farmers in the same village. Geographic variation in production costs follow differences in agro-ecological suitability for maize production and input costs. The average production cost per bag varied from as low as ZMK 34,000 in the Eastern and Northern Provinces (representing 35% of national production) up to ZMK 53,000 in the Copperbelt and Western Provinces (10% of national production). Within-village production cost differences arise due to differences in farmer ability and knowledge and the various management decisions they make.

These sources of variation result in a wide range of production costs, which leads to the conclusion that there is no single "cost of maize production". There is only a distribution of production costs across the millions of maize farmers in Zambia. In fact, the most productive 20% of farmers in the 2010 CFS produced maize at a mean of ZMK 15,567 per bag. The next most production 20% of farmers production costs were ZMK 29,078 per bag. Mean production costs for the third and fourth quintiles were ZMK 42,776 and ZMK 64,341 per bag, respectively. The least productive maize farmers' production costs were well over ZMK 100,000 per bag, which in many cases reflected unexpected events leading to partial or near total crop losses. In such cases, production expenses are extremely high when expressed relative to bags produced.

The second key observation from the analysis in this report is that in 2010, the only year for which data are available, 86% (2.06 million MT) of Zambia's total maize output was produced at a total cost lower than the 65,000 ZMK/bag FRA buying price. The mean total cost of production per bag was ZMK 40,739. Cash expenditure on inputs per bag was ZMK 18,630 on average.

Thirdly, the majority of Zambian maize could be sold at a profit competitively in regional markets. At the beginning of the harvest season, the export parity price in Kabwe was roughly ZMK 59,000. Meanwhile, 1.8 million metric tons of Zambian maize was produced at costs lower than 50,000 ZMK/bag. Moreover, those with a recent history of selling and those expecting to sell maize had lower than average production costs (roughly 38,000 ZMK/bag). Among this group it is estimated between 76 and 82% of the maize produced could have been competitive in regional export markets.

Fourth, there is a strong correlation between higher yields and lower costs of production. This is not surprising. Clearly, a key factor in increasing Zambian maize producers' comparative advantage in the region will be the promotion of productivity enhancing technologies and agronomic practices.

Fifth, rural smallholder production remains highly labor-intensive. On average, family labor accounts for 62% of the total cost of maize production in Zambia's small- and medium-scale farm sector. Promoting the identification and adoption of practices and technologies that save labor and /or identifying labor-productivity-enhancing technologies through research and development will therefore help to make maize production profitable for Zambian farmers even at lower producer prices.

Finally, we find that many productivity-enhancing technologies are in use in Zambia and in many cases, they are cost effective. First, we demonstrate that, rather than driving up cost of production per bag, fertilizer use is profitable under the right conditions. That said there is also evidence of fertilizer users who do not see positive returns. Reasons for this could include poor management practices, late availability and hence application of fertilizer, crop damage due to flooding or pests, and fertilizer use in areas where the crop response rate to fertilizer application is low, such as under highly acidic soil conditions. Furthermore, there is evidence of several other technologies being employed in Zambia that also may enhance productivity. For example, regression analysis suggests several tillage methods (including plowing, ripping, zero tillage, basin planting, and ridging) show signs of raising gross margins and/or reducing production cost per bag. Herbicides, which are currently applied to roughly only 3% of maize fields, significantly contributed to higher gross margins per hectare planted, despite the additional cash investment added to production cost per hectare. Extending knowledge of tillage practices and their benefits as well as appropriate input use to smallholders may be a relatively high-return policy option.

APPENDICES

APPENDIX A

Table A1. Median Hourly Wage by Province for Maize Related Production Activities

	Province								
	Central	Copperbelt	Eastern	Luapula	Lusaka	Northern	N. Western	Southern	Western
Land preparation	1,500	1,389	1,375	1,195	1,333	823	677	3,000	1,667
Planting	1,771	1,615	972	781	2,000	833	1,042	2,500	945
Basal Dressing	1,615	1,458	690	1,000	1,833	833	1,486	1,949	408
Top Dressing	1,615	1,339	714	1,000	2,083	817	1,417	1,667	333
1st Weeding	863	952	866	762	1,042	578	583	732	722
2nd Weeding	967	774	625	732	955	500	521	950	528
3rd Weeding	476	476	862	694	1,042	440	419	536	323
Harvesting	938	714	690	586	938	670	732	458	833
Transporting to homestead	2,500	1,667	2,241	741	1,333	625	833	2,232	2,500
Shelling and Packing	804	833	525	567	670	469	760	1,000	600

Source MACO/CSO Crop Forecast Survey 2010

Table A2. Sensitivity Analysis of Fertilizer Pricing

Province	All fertilizer valued at: FISP price	Actual price paid by household	Commercial price
	Mean Gross Margin (ZMK/ha)		
Central	1,301,851	1,174,405	1,073,966
Copperbelt	751,595	624,710	543,293
Eastern	1,265,839	1,209,806	1,160,080
Luapula	1,103,493	1,060,497	883,261
Lusaka	1,200,391	1,066,892	956,950
Northern	1,926,248	1,824,673	1,661,959
North Western	1,054,382	1,028,417	902,919
Southern	964,549	887,101	858,243
Western	248,426	238,925	224,096
All Zambia	1,185,272	1,108,542	1,022,061

Source MACO/CSO Crop Forecast Survey 2010

Table A3. Sensitivity Analysis of Family Labor Wage Rates

Province	Opportunity cost of family labor valued at: Zero	Local wage rate	ZMK 8500/day
	Mean Gross Margin (ZMK/ha)		
Central	2,515,364	1,174,405	618,297
Copperbelt	2,457,816	624,710	-532,059
Eastern	2,095,651	1,209,806	367,329
Luapula	2,536,805	1,060,497	-588,944
Lusaka	2,516,662	1,066,892	375,222
Northern	2,916,749	1,824,673	322,174
North Western	2,258,916	1,028,417	-442,387
Southern	2,011,335	887,101	606,121
Western	1,668,617	238,925	-601,771
All Zambia	2,314,926	1,108,542	166,495

Source MACO/CSO Crop Forecast Survey 2010

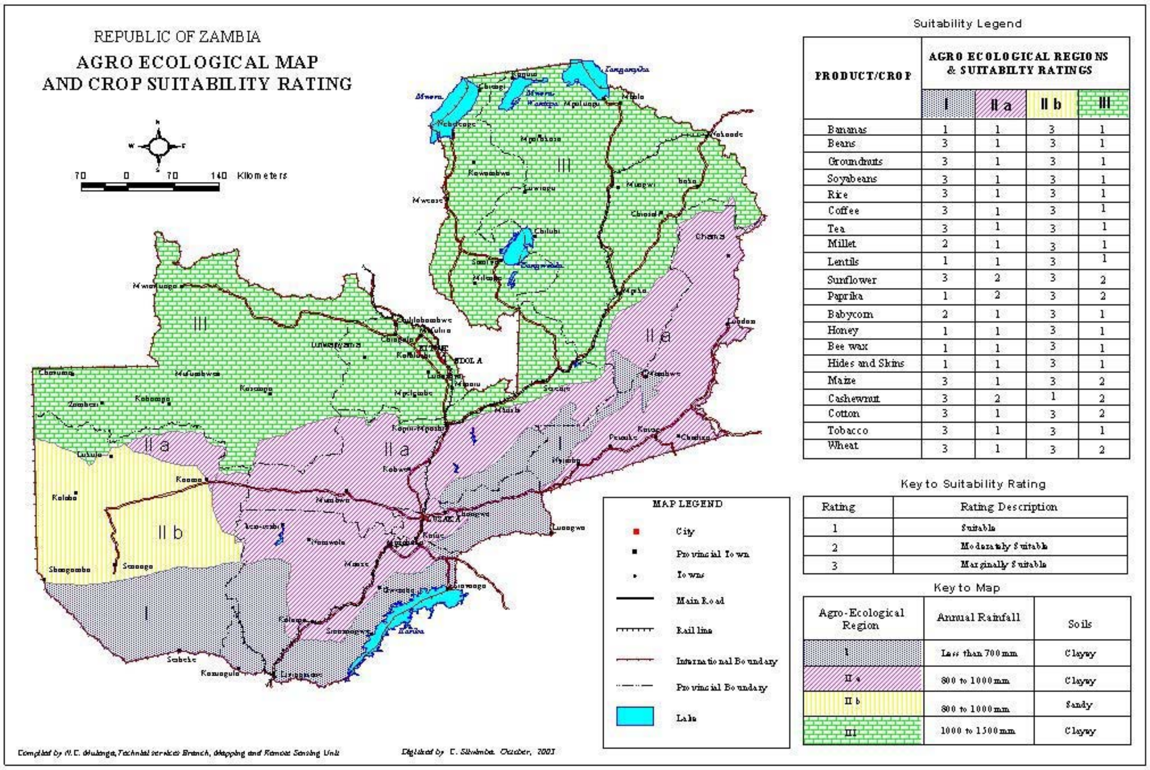
APPENDIX B

Table B1. Maximum Accepted Response for Various Labor-related Questions

Variable	Maximum value	% of valid activity-level responses affected	% of all activity-level responses affected
Number of employees hired	20 workers	0.7%	0.0%
Days each hire is employed	Land Prep: 60 days Other: 30 days	0.0%	0.0%
Time worked per employee per day	10 hours	1.2%	0.0%
Number of working household men	Determined by demographics data	19.1%	12.5%
Number of working household women	Determined by demographics data	19.8%	13.0%
Number of working household boys	Determined by demographics data	5.1%	3.4%
Number of working household girls	Determined by demographics data	4.1%	2.7%
Days household members worked	Land Prep: 60 days Other: 30 days	0.7%	0.0%
Time worked per member per day	10 hours	0.8%	0.0%

APPENDIX C

Figure C1. Zambian Crop Suitability Map



PRODUCT/CROP	AGRO ECOLOGICAL REGIONS & SUITABILTY RATINGS			
	I	II a	II b	III
Bananas	1	1	3	1
Beans	3	1	3	1
Groundnuts	3	1	3	1
Soyabeans	3	1	3	1
Rice	3	1	3	1
Coffee	3	1	3	1
Tea	3	1	3	1
Millet	2	1	3	1
Lentils	1	1	3	1
Sunflower	3	2	3	2
Paprika	1	2	3	2
Babycorn	2	1	3	1
Honey	1	1	3	1
Bee wax	1	1	3	1
Hides and Skins	1	1	3	1
Maize	3	1	3	2
Cashewnut	3	2	1	2
Cotton	3	1	3	2
Tobacco	3	1	3	1
Wheat	3	1	3	2

Rating	Rating Description
1	Suitable
2	Moderately Suitable
3	Marginally Suitable

Agro-Ecological Region	Annual Rainfall	Soils
I	Less than 700mm	Clayey
II a	800 to 1000mm	Clayey
II b	800 to 1000mm	Sandy
III	1000 to 1500mm	Clayey

Source: GRZ 2007

APPENDIX D

Table D1. Costs of Production by 2009 Market Participation and Expected 2010 Position

	Production Costs		
	Cash expenditures	All non-land costs	Total Cost
Market Position 2009	Household average (ZMK/50kg)		
Did not sell	13,991	57,155	66,076
Sold to FRA only	22,935	43,245	47,403
Sold to private buyer only	18,745	50,568	57,006
Sold to FRA and Private buyer	24,919	44,942	48,734
Expected Market Position 2010			
Do not expect to sell	13,714	62,875	73,075
Expect to Sell	18,624	45,551	50,943
All Zambia	16,139	54,318	62,143

Source: MACO/CSO Crop Forecast Survey 2010

Table D2. Costs of Production by 2009 Market Participation and Expected 2010 Position

	Production Costs		
	Cash expenditures	All non-land costs	Total Cost
Market Position 2009	Production weighted (per bag) average cost (ZMK/50kg)		
Did not sell	14,315	42,949	48,862
Sold to FRA only	22,172	35,767	38,954
Sold to private buyer only	21,101	41,474	45,853
Sold to FRA and Private buyer	22,894	35,629	38,712
Expected Market Position 2010			
Do not expect to sell	13,751	49,912	57,326
Expect to Sell	20,061	38,278	42,247
All Zambia	18,679	40,826	45,550

Source: MACO/CSO Crop Forecast Survey 2010

REFERENCES

ACF/FSRP. 2010. *Talking Points: Supply, Demand, Prices and Marketing for the 2010/2011 Zambian Maize Marketing Season*. April 23. On line at: http://www.aec.msu.edu/fs2/zambia/Talking_points_maize_situation_2010_2011.pdf

GRZ. 2007. *National Adaptation Programme of Action on Climate Change (Final Report)*. Lusaka: Ministry of Tourism, Environment, and Natural Resources. Mimeo.

MACO/CSO. 2010. Crop Forecast Survey, jointly implemented by the Ministry of Agriculture and Cooperatives and Central Statistical Office. Lusaka: Government of Zambia.