DEPARTMENT OF AGRICULTURAL ECONOMICS AND EXTENSION

WORKING PAPER

CASH CROPPING INCENTIVES, FOOD MARKETING PERFORMANCE
AND THE DIVERGENCE BETWEEN NATIONAL AND HOUSEHOLD
COMPARATIVE ADVANTAGE EVIDENCE FROM ZIMBABWE

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Working Paper AEE 3/92

Cash Cropping Incentives, Food Marketing Performance and the Divergence between National and Household Comparative Advantage Evidence from Zimbabwe

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APRIL 1992

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I. Introduction

A growing body of evidence throughout Sub-Saharan Africa argues for the pursuit of a food security strategy based on diversification of smallholder agriculture into high-valued cash crops.[1] The empirical record suggests that, in many semi-arid areas, cash crops such as cotton, sunflower and groundnut provide higher returns to land and labor than food grains and thus present major opportunities to promote smallholder income growth, food security and national foreign exchange generation. Empirical findings have also shown that, to the extent that food and cash crops require labor or draft inputs at different periods, crop diversification may generate a significantly higher value of output for a given bundle of inputs.[2]

In spite of these findings, smallholders in most semi-arid areas of Africa continue to devote up to 90% of their cropped land to food grains. This is especially ironic in the semi-arid areas, considering the drought-tolerance of oilseeds compared with maize and sorghum. While several constraints to the expansion of cash cropping are well known -- poor seed delivery systems, disease and pest problems, and risks associated with acquiring food from unreliable markets where prices and availability fluctuate considerably -- the expected profitability of these crops relative to grain crops has normally not been questioned.

This paper suggests that cash crop production may be economically unviable -- despite providing higher returns to land and labor than grain crops -- in an environment of high food marketing costs to rural areas. A simple conceptual model is presented to show that the seemingly higher financial returns to cash crops over grain production are based on the implicit assumption that farmers are self-sufficient in grain. Evidence suggests, however, that most farm households in the semi-arid areas of Sub-Saharan Africa are net grain purchasers despite devoting the bulk of their resources to grain production. For these households, the opportunity cost of cash crop production is not the net returns to growing and selling food grains, but rather the cost of acquiring the grain foregone by cultivating cash crops, which is related to acquisition costs of grain rather than selling prices. Typical assessments of crop profitability (e.g., returns to land and labor) may be based on the wrong prices, and thus provide misleading information to national extension services and policy makers about desired crop composition to raise farm incomes and national agricultural growth. Large wedges often observed between rural producer and consumer grain prices may make cash crop production unprofitable until enough grain is planted for household consumption requirements.

These theoretical implications are supported by econometric evidence from Zimbabwe indicating that cultivation of various oilseed crops for the market, which often provide substantially higher rates of return under semi-arid smallholder conditions than grain, is closely associated with the degree of grain self-sufficiency of the household. Controlling

for differences in household assets and location, grain-surplus households in five semi-arid regions of Zimbabwe were found to cultivate 48% more oilseed crops for the market than their grain-deficit neighbors. The results indicate that, in situations where productivity gains through new technology are not on the immediate horizon, policy efforts to raise rural incomes through crop diversification are critically dependent on the development of food markets that reduce the consumer price of staple grain in rural areas. Moreover, the micro-level effects of artificially high food marketing costs on cropping patterns and household incomes may have important macro-level reverberations by skewing cropping patterns away from those of comparative advantage and agricultural growth. Finally, the results suggest that the direction of causality between cash crop production and household income may run both ways: those households that engage in substantial cash cropping may have higher incomes, yet in an environment of high food marketing costs, the ability to engage in cash cropping appears dependent on adequate household productive assets over and above those needed for subsistence grain production needs.

II. Conceptual Framework

Typically, when commodities such as food are bought and sold by smallholders, the farm-gate price is some fraction of the purchase price. The width of the wedge between these prices is a function of transportation infrastructure, policy-related factors, and institutions which coordinate exchange across space, time and form. Moreover, risks associated with uncertain prices and supplies create perceived certainty-equivalent prices that are lower than observed farm-gate prices and higher than observed purchase prices, thus further widening the price wedge.[3]

The evidence is now overwhelming that throughout much of semi-arid Sub-Saharan Africa, a large proportion of rural farm households cannot or do not produce enough grain to feed themselves and are purchasers of grain.[4] Therefore, returns to crop production *for sale* may not accurately represent the relative profitability of alternative crops. For grain-deficit households, the decision to grow a hectare of cash crops must be at the expense of a hectare of food grain for home consumption. In this case, the decision facing the smallholder is whether to (1) grow oilseed or other crops for cash to buy back grain for home use, or (2) produce the grain directly for home use. The relevant grain price in Strategy (1) is the cost of acquiring staple grain, not the producer price. Strategy (1) is a food security strategy based on the argument that income from cash crop cultivation can buy back more grain than could have been produced if those same resources were devoted to food crop production. Strategy (2) would have the manifestation of an apparent food self-sufficiency strategy, but would also represent a more productive use of available household resources if the income generated from cash crop cultivation on an additional unit of land were not sufficient to buy back the quantity of grain for consumption that could have been produced on that unit of land. For all farmers, the decision rule for choice of crop on each additional hectare put under cultivation is: grow cash crops if

2

$$Y_i > D[PP_{gr}Q_{gr} - C_{gr}] - (1-D)[Q_{gr}sx(PC_{gr} - m) - C_{gr}] \qquad (1)$$

where:
- Y_i = expected gross margin of cash crop i (Z\$/hectare);
- D = 1 if, given the outcome of the decision rule of the previous marginal hectare, the household expects to be food self-sufficient;[5]
  = 0 if, given the outcome of the decision rule of the previous marginal hectare, the household expects to be food deficit;
- PP_{gr} = grain producer price (Z\$/kg);
- Q_{gr} = expected grain production per hectare (kgs/hectare);
- C_{gr} = grain variable costs of production (Z\$/hectare);
- s = proportion of grain production that is consumable over one year, accounting for storage losses (% of kgs produced);
- x = extraction rate from grain to meal (%);
- PC_{gr} = acquisition price of grain meal in rural area (Z\$/kg);
- m = milling cost to convert grain to meal (Z\$/kg);

If, given the allocation decisions on the previous land units, the household expects to be grain surplus (D=1), the decision rule reduces to a simple comparison of gross margins from grain and oilseed crop i. If, however, the household expects to be grain-deficit, cultivation of oilseed crop i means that one hectare of maize for home consumption is foregone. The second bracketed term, $[Q_{gr}sx(PC_{gr} - m) - C_{gr}]$, accounts for the net cost of purchasing the amount of grain meal that could have been produced on that hectare, accounting for storage losses, grain-to-meal milling losses, milling costs and production costs incurred if the household produced and processed the grain itself.

This model suggests that, *ceteris paribus*, the viability of producing oilseeds by net grain purchasing households is negatively related to the acquisition price of grain meal, not the producer price of grain. The greater the wedge between these producer and consumer prices, the greater the divergence in the value of grain by grain surplus and deficit households. The higher the acquisition cost of staple food relative to producer prices for cash crops, the less incentive for grain-deficit households to diversify, *ceteris paribus*.

In many sub-Saharan African countries, marketing margins between producer and consumer food prices are large compared with those in other developing areas.[6] The organization of official grain marketing systems in many East and Southern African countries features a predominantly one-way flow of grain from rural to urban areas and is characterized by centralized urban milling and storage facilities.[7] This structure implicitly assumes rural self-sufficiency in grain. Moreover, national food policies often restrict private movement of grain directly from surplus to deficit rural areas and thus inflate marketing costs and consumer prices in the latter areas. In some countries such as Zimbabwe, a circuitous flow of grain has evolved in which marketed grain surpluses flow out of rural areas through the official marketing channel to be milled in urban areas and are then returned to other rural areas in the form of commercial maize meal.[8] Because of superfluous transport costs and relatively high milling margins of centralized urban millers, the price of commercial maize meal is typically 110% to 140% higher than the official producer price.[9]

How does the large wedge between producer and consumer maize prices affect smallholder incentives to produce groundnuts and sunflower, the major non-food cash crops in semi-arid Zimbabwe? By rearranging inequality (1) slightly, the net revenue remaining to the household (Z_i) from planting oilseed crop i rather than grain is:

$$Z_i = Y_i - D[PP_{gr}Q_{gr} - C_{gr}] - (1-D)[Q_{gr}sx(PC_{gr} - m) - C_{gr}] \qquad (2)$$

In order to assess whether the wedge between producer and consumer maize prices is large enough to alter the sign of Z_i for grain surplus and deficit households, equation (2) is calculated using survey data on crop production costs and returns in four semi-arid smallholder areas collected by the Ministry of Lands, Agriculture and Rural Resettlement (MLARR).[10]

Results are presented in Table 1. For households that are grain surplus, the oilseed crops give clearly higher rates of return to land and labor (not shown) in all areas. These results are consistent with those of the World Bank,[11] which also indicate that sunflower and groundnut provide consistently higher returns to land, labor and capital than the grain crops in the semi-arid areas. This type of analysis implicitly assumes self-sufficiency in grain, i.e., that the opportunity cost of using farm resources for oilseed production is the returns from alternative crops for sale.

When the assumption of grain self-sufficiency is relaxed, oilseed production becomes distinctly less viable. In seven of nine cases where oilseeds gave higher gross margins than maize, this result was reversed when the opportunity cost of this land was conceived in terms of grain foregone for consumption (valued at the consumer price) rather than grain foregone for selling (at the producer price). These contrasting results are due to the large difference between maize producer prices and consumer maize meal costs.[12]

III. The Model

The foregoing suggests that, in the areas analyzed by MLARR, smallholders may have little incentive to produce oilseeds for the market until enough land and resources have been devoted to grain for self-sufficiency. Beyond this point, however, one may expect that extra productive resources would be increasingly used for cash crop production, if these crops provide higher returns for sale. It does not follow that all remaining land and resources in excess of that required for grain self-sufficiency should be devoted to oilseeds, because of various non-market purposes for growing surplus grain such as gifts, beer brewing for ceremonial functions, livestock feed and insurance stocks. In addition, recent research from elsewhere in Africa indicates that there are important complementarities between grain and cash crop production. In Senegal, Goetz found that crop diversification allowed farmers to more fully utilize farm inputs, to the extent that food and cash crops require labor or draft inputs at different periods, and thus generate a higher value of output for a given bundle of inputs.[13] In southern Mali, Dione found that households producing cotton were more likely to have animal traction equipment, access to credit and technical inputs, and as a result produce more grain crops.[14]

The discussion leads to two specific empirical questions:

Q1: is oilseed cultivation higher, *ceteris paribus*, among grain-surplus households than grain-deficit households?; and

Q2: if complementarities exist between grain and oilseed production, is there any difference in the ability to exploit them between grain-deficit and surplus households?

Note that these questions do not stem from behavioral assumptions about smallholders responses to market and production risks, although these factors are undoubtedly important in many areas. While it is often noted that smallholders appear to strive for grain self-sufficiency along with any new ventures into cash cropping, it is unlikely that risks associated with the availability or price of staple grain are important causes of this behavior in Zimbabwe, since staple maize meal is consistently available throughout the year at fixed prices (or slightly above) even in the most remote areas. Moreover, Zimbabwe's Grain Marketing Board, which buys the bulk of smallholder grain and sunflower sold nationally, offers fixed prices with no variation within years and very little variation in real prices between years. Rather, Q1 and Q2 are based on the theoretical implications from Section II that oilseed cultivation for sale may not be economically viable for grain-deficit households -- despite providing higher returns to land and labor than grain -- depending on the level of food marketing costs and consumer prices in rural areas.

Q1 and Q2 are examined econometrically using cross-sectional survey data from 495 households in five semi-arid smallholder areas in Zimbabwe. It is widely considered that, due to yield variations, area planted is a more accurate reflection of resource allocation than *ex post* production outcomes, hence the use of oilseed area as the dependent variable.[15] Area planted to oilseeds was regressed on predetermined variables entering a standard production function such as number of draft animals, labor input and capital equipment, as well as the degree of household grain self-sufficiency. Since decisions affecting grain self-sufficiency are not made independently of area planted to oilseeds, estimated values from two auxiliary equations are used in the estimation of oilseed area. With the symbol "*" denoting an estimated value, the set of equations is:

$$y_1 = f_1(x) + e_1 \tag{3-a}$$

$$SSL^* = y_1^* + ST - REQ \tag{3-b}$$

$$y_2 = f_2(x, SSL^*) + e_2 \tag{3-c}$$

where y_1^* is the predicted value of grain production used to estimate the level of grain self-sufficiency (SSL^*), x is a vector of predetermined household asset variables described below, ST is household grain stocks at the beginning of the harvest period, REQ is grain consumption requirements (based on the number of resident adults and children),[16] and y_2 is area planted to oilseed crops with the intention of sale. Both grain stocks and consumption requirements are considered known with reasonable accuracy at planting time. Prices of oilseeds and grain crops were excluded because the Grain Marketing

Board's policy of pan-territorial and pan-seasonal pricing creates a lack of observed price variation among households.

Q1 and Q2 may be tested in equation (3-c) by allowing the slope and intercept linking cash crop area to the degree-of household grain self-sufficiency to change at the point at which self-sufficiency is reached. The specification of (3-c) used here is

$$y_2 = a0 + a_1(L) + a_2(DRAFT) + a_3(EQUIP)$$
$$+ \sum_{j=1}^{4} b_j(LOC_j) + a_4(SSL^*) + a_5(D) + a_6(SSL^*)D \qquad (4)$$

where L is household labor expressed in adult equivalents, DRAFT is the number of draft animals, EQUIP is the value of animal traction equipment owned, and LOC_j are area-specific dummy variables to account for variations in soil, rainfall, and infrastructural conditions between households in different regions. D is a dummy variable which takes on a value of one for households in which $SSL^* > 0$ and zero otherwise. Under the assumption that oilseed cultivation is not influenced by the achievement or the degree of grain self-sufficiency, a_5 and a_6 equal zero and equation (4) reduces to

$$y_2 = a0 + a_1(L) + a_2(DRAFT) + a_3(EQUIP) + a_4(SSL^*)$$
$$+ \sum_{j=1}^{4} b_j(LOC_j) \qquad (5)$$

Using regression results from equations (4) and (5), Q1 may be empirically examined via an F-test of the joint hypothesis that $a_5 = a_6 = 0$. Q2 may be examined by comparing the magnitude and significance of a_4 and a_6.

IV. Data and Characteristics of the Sample

The cross-sectional household data was drawn from field surveys of 495 families selected randomly within 20 wards in five smallholder areas between April 1990 and March 1991. Average annual rainfall within each region ranges from 400 - 700 mm. Rainfall during the production period was slightly below average.

To facilitate visual comparison, the total sample of households was stratified into quintiles according to their net grain sales during the year.[17] Characteristics of these grain quintiles are summarized in Table 2. Across all quintiles, grain and oilseeds constituted 76% and 19% of total cropped area. The proportion of households growing oilseeds with the intention of selling varied from 33% among the bottom grain quintile to 63% among the top quintile. The most common responses among households in the grain-deficit quintiles as to why they did not grow more grain to feed themselves were lack of sufficient land and draft power. This is in spite the fact that an average of 79% of their cropped land was already devoted to grain.[18] On the other hand, smallholders in the grain-surplus quintiles increasingly mentioned the profitability of other crops as the main reason why they did not plant more grain.

The distribution of land, value of equipment and number of draft animals among households varied widely between households in different quintiles. Other researchers

have also noted a very skewed distribution of land, draft animals and other productive resources among smallholder households.[19] This may explain why approximately 10% of the relatively well-equipped households typically account for over 50% of the grain crop income generated in these areas. The grain-surplus quintiles also had, on average, substantially higher per capita incomes from farm and non-farm sources.

V. Results

Coefficient estimates for equations (4) and (5) are presented in Table 3. All household asset variables had the expected sign and were significant at the 5% level or lower, with the exception of household labor. The hypothesis that oilseed cultivation did not differ between grain surplus and grain-deficit households, i.e., that $a_5 = a_6 = 0$, was rejected at the .05 level of significance. Controlling for differences in household assets and location, grain-surplus households were estimated to cultivate, on average, 0.70 hectares of oilseed crops for the market compared with 0.47 hectares by their grain-deficit neighbors. In the driest and most grain-deficit location, oilseed area was estimated .04 hectares and .27 hectares for grain-deficit and grain-surplus households, respectively. The sign of a_4 indicates no complementarities between grain and oilseed production among grain-deficit households. However, once the point of self-sufficiency is reached, household oilseed cultivation is estimated to increase by 0.21 hectares for every additional ton of grain produced.

Note that these empirical results pertain to a market environment in which staple grain meal is consistently available throughout the year at stable prices. Price monitoring surveys conducted bi-weekly in a broad range of rural areas in Zimbabwe indicate that the controlled selling prices of commercial maize meal, set by government, are normally respected and appear to be exceeded by at most 10% even in the most remote rural areas.[20] Moreover, historical reviews of grain marketing policy since 1980 indicate that commercial maize meal was in short supply in rural areas only once (1983) due to government pricing policy in which subsidies on commercial maize meal (removed entirely since 1986) were so large that the milling capacity of urban processors was temporarily exceeded. While smallholders' observed self-sufficiency behavior is commonly attributed to market risks associated with fluctuations in food price and availability, and is undoubtedly important in many developing areas, this explanation does not appear compelling in other areas such as Zimbabwe.

VI. Conclusions and Policy Implications

Assessments of relative profitability between food and cash crops are typically made with reference to producer prices of alternative crops and thus implicitly assume that farmers are food self-sufficient. Such calculations may not accurately reflect the most economic use of farm resources in food deficit areas since these calculations do not measure the true opportunity cost of devoting scarce productive resources to non-food crops. Such analyses may provide misleading information to national extension services and policy makers about desired crop mix to raise smallholder incomes and food security.

Smallholders' overriding concern with food self-sufficiency, commonly explained in terms of risk aversion, may also be explained on the basis of expected net returns in an environment of high food marketing margins and acquisition costs in rural areas. Despite providing higher returns for sale, the strategy of oilseed production/food purchase appeared to be unprofitable relative to food production for grain-deficit households in seven of nine cases analyzed. Econometric results from five survey areas of Zimbabwe also indicate that, in general, grain-deficit households are purchasers not because they are growing higher-valued crops with which to buy food, but because they do not have the productive resources to grow enough staple food to feed themselves.

While mounting evidence from a wide range of developing areas indicates that those smallholders that engage in substantial cash cropping have higher incomes than those that do not,[21] the direction of causality has not been adequately examined. The correlation between cash cropping and household income, while often interpreted as evidence to promote cash cropping, would also result from a situation in which diversification were generally undertaken by households that possessed sufficient purchased inputs and farm assets to assure food self-sufficiency and used residual resources to expand into cash cropping. Not surprisingly, numerous studies throughout Africa have found that household food production, cash crop production and per capita incomes are all highly correlated.[22]

How much lower must the consumer price of staple meal be in Zimbabwe in order to make oilseed production viable for grain-deficit smallholders? The answer to this question can be found by setting net revenue in equation (2) to zero and solving for PC_{gr}. These threshold consumer prices for grain meal are presented in the last column of Table 1. In several cases, these threshold prices are less than 15% lower than the current price of commercial maize meal. This is noteworthy because previous research in Zimbabwe has estimated that the current controls on grain movement, which restrict grain from moving directly from surplus to deficit areas, inflate consumer grain prices by as much as 25%.[23]

Removal of such restrictions and active support for the development of intra-rural trade could simultaneously contribute to governments' food security and agricultural growth objectives, by both reducing the cost of food purchased and by raising the value of farm output sold. Such policies are apparently neglected because of the conventional perception that farm households are predominantly food self-sufficient. This misconception underscores the negative effects of uni-directional single-channel state marketing systems commonly found in East and Southern Africa, which are primarily geared to extract grain out of rural areas and into urban milling, storage and consumption centers.

Available domestic resource cost analyses in Zimbabwe indicate that oilseed crops tend to be more efficient generators of foreign exchange than grain crops.[24] Thus, more efficient rural food markets, to the extent that they reduce the opportunity cost of cash crop production, may be an important precondition for stimulating dynamic changes in crop mix more consistent with comparative advantage, agricultural growth and foreign exchange generation. This must, of course, be complemented by institutional and technological improvements within the cash crop sub-sectors themselves.

Several caveats to this analysis must be discussed for more detailed examination in future research. First, the analysis examines the effect of a household being grain deficit on its incentives to grow oilseeds for sale. The analysis does not examine household incentives to grow oilseeds for own consumption, gifts, or other non-market purposes. Second, the analysis does not examine the effect of production risk on the relative incentives to grow oilseeds, which may be especially relevant in semi-arid areas prone to frequent drought. In such cases, the yield stability of grains vs. oilseeds becomes important. The risk of drought may induce households to put more of their land in grain to assure adequate supplies even under poor yield conditions. Finally, the analysis did not examine how off-farm employment opportunities affect grain and cash crop production. The introduction of a competing source of labor income may alter the trade-offs somewhat between grain and oilseed production. However, the wedge between producer and consumer food prices creates the same dual calculation for off-farm employment as for cash crops, in so far as off-farm employment may provide higher returns to labor than those to production of food valued at the selling price, but not necessarily at the purchase price.

Further analysis of the relationship between rural food markets and alternative crop production in other countries would help gauge the robustness of these results.

Notes

1. See, for example, Joachim von Braun, Eileen Kennedy and Howarth Bouis, "Commercialization of Smallholder Agriculture: Policy Requirements for the Malnourished Poor," Food Policy 15 (February 1990): 82-85; Eileen Kennedy, "The Effects of Sugarcane Production on Food Security, Health, and Nutrition in Kenya: A Longitudinal Analysis" (Research Report 78, International Food Policy Research Institute, Washington, D.C. 1989). David Sahn, "The Impact of Export crop Production on Nutritional Status in Cote d'Ivoire," World Development 18 (December 1990): 1635-53.

2. Stephan Goetz, "Interlinked Markets and the Cash Crop-Food Crop Debate in Land-Abundant Tropical Agriculture," submitted to Economic Development and Cultural Change, 1991; Josue Dione, "Informing Food security Policy in Mali: Interactions between Technology, Institutions and Market Reform." Unpub. PhD Dissertation, Michigan State University, East Lansing, Michigan, 1989.

3. A. deJanvrey, M. Fafchamps and E. Sadoulet, "Peasant Household Behavior with Missing Markets: Some Paradoxes Explained," (Working Paper 578, Department of Agriculture and Resource Economics, University of California at Berkeley, 1991).

4. See surveys across regions and countries by Michael Weber, John Staatz, John Holtzman, Eric Crawford, and Richard Bernsten, "Informing Food Security Decisions in Africa: Empirical Analysis and Policy Dialogue," American Journal of Agricultural Economics 70 (December 1988): 1044-52; and Per Pinstrup-Andersen, "Government Policy, Food security and Nutrition in Sub-Saharan Africa," (PEW/Cornell Lecture Series on Food and Nutrition Policy, Cornell University, Ithaca, 1989).

5. The level of food self-sufficiency must be an ex ante evaluation because the relationship between land, labor and capital inputs and actual production is uncertain due to stochastic yields.

6. R. Ahmed and N. Rustagi, "Marketing and Price Incentives in African and Asian Countries: A Comparison," in Agricultural Marketing Strategies and Pricing Policy, ed. Dieter Elz (Washington, D.C.: World Bank, 1984).

7. For further evidence of the extractive aspects of official marketing systems in Tanzania, Malawi, Zimbabwe and Zambia, see H.K.R. Amani and W.E. Maro, "Household Food Security in Tanzania: Preliminary Findings from Four Regions," in Market Reforms, Research Policies and SADCC Food Security," eds. M. Rukuni and J.B. Wyckoff (University of Zimbabwe/Michigan State University Food Security Research in Southern Africa Project, Department of Agricultural Economics, University of Zimbabwe, 1990); B. Kaluwa and W. Chilowa, "Malawi: Food Marketing Liberalization and Household Food Security," in eds. Rukuni and Wyckoff; T.S. Jayne and M. Chisvo, "Unravelling Zimbabwe's Food Insecurity Paradox: Implications for Food Security in Southern Africa," Food Policy 16 (August 1991); and Republic of Zambia, "Evaluation of the Performance of Zambia's Maize Subsector," Zambia Agricultural Training, Planning and Institutional Development Project II, Lusaka, 1990.

8. Jayne and Chisvo, 1991, *op cit.*

9. Despite this large marketing margin, the GMB is still the dominant buyer in most areas of the country, and commercial maize meal constitutes the most important form of grain purchases in many of the semi-arid rural areas. The dearth of private trade which might otherwise buy and sell within these official price margins is largely due to tight controls on private grain movement and resale.

10. Government of Zimbabwe/Ministry of Lands, Agriculture and Rural Resettlement, "The First Annual Report of Farm Management Data for Communal Area Farm Units', Economics and Markets Branch, Harare, 1990. Milling costs (Z$0.052 per kilogram) and grain-to-meal conversion rates facing the household (0.97) are drawn from Jayne and Chisvo. Storage loss factors under smallholder conditions are drawn from D.P. Giga and J. Biscoe, "Treating Maize Grain for Storage with Registered Protectants in Zimbabwe: Technical, Practical and Economic Considerations," The Zimbabwe Science News 23 (October/December 1989), 101-103.

11. World Bank, "Zimbabwe Agricultural Sector Memorandum, Volume II: Main Report," (Agricultural Operations Diversion, Washington, D.C., 1991).

12. Although this discussion is based on gross margin analysis, the conclusions are essentially the same if equation (2) is modified to measure returns to labor. The focus here is on returns to land because land is considered the binding resource constraint in most smallholder areas of Zimbabwe. This is supported by responses (presented in table 2) by grain-deficit households that insufficient land was the most important constraint on increased grain production.

13. S. Goetz, "Economies of Scope and the Cash Crop-Food Crop Debate in senegal," draft mimeo, Department of Agricultural Economics, University of Kentucky, Lexington, 1991.

14. Dione, *op cit.*

15. H. Askari and J. Cummings, "Estimating Agricultural Supply Response with the Nerlove Model: A Survey," International Economic Review 18, No. 2 (1977): 257-92.

16. Adult grain consumption requirements in Zimbabwe were drawn from SADCC, "Food Security Bulletin," (SADCC Regional Early Warning Unit for Food Security, Harare, Zimbabwe, 1991).

17. Net grain sales is defined as total monetary and barter sales minus total monetary and barter purchases.

18. Results of other household surveys in semi-arid regions of Zimbabwe also indicate that most grain-deficit farmers are unable to expand grain production, not because they are devoting substantial land to other crops, but because of resource constraints: limited land, draft animals, and non-farm income to finance investments in

11

improved technology, poor soil and erratic rainfall; Jones Govereh, "Constraints to Increased Crop Productivity in Two Low Rainfall Areas of Zimbabwe," unpublished M.Phil thesis, Department of Agricultural Economics and Extension, University of Zimbabwe, 1990.

19. Jayne Stack and Charles Chopak, "Household Income Patterns in Zimbabwe's Communal Areas: Empirical Evidence from Five Survey Areas," Integrating Food and Nutrition Policy in Zimbabwe, eds. T.S. Jayne, J.B. Wyckoff and M. Rukuni (University of Zimbabwe/ Michigan State University Food Security Project, Department of Agricultural Economics and Extension, University of Zimbabwe, Mount Pleasant, 1990).

20. University of Zimbabwe/Michigan State University/ ICRISAT Grain Marketing Surveys, 1990-91.

21. For a summary of recent surveys in Kenya, the Gambia, Guatemala, the Philippines and Rwanda, see Von Braun et al.

22. See, for example, Dione; Goetz; Jayne Stanning, "Smallholder Maize Production and Sales in Zimbabwe," Food Policy 4 (August 1989): 260-67; and J. Jackson and P. Collier, "Incomes, Poverty and Food Security in the Communal Lands of Zimbabwe," (Rural and Urban Planning Occasional Paper 11, Department of Rural and Urban Planning, University of Zimbabwe, 1988).

23. Jayne and Chisvo, op cit.

24. Will Masters, "Dynamic Comparative Advantage of Sorghum and Millets in Zimbabwe," (report prepared for SADCC/ICRISAT/Sorghum and Millets Improvement Program, Zimbabwe, 1990); Michael Roth, "Analysis of Agrarian Structure and Land Use Patterns," (Background paper for Zimbabwe Agricultural Sector Memorandum, World Bank, Harare, Zimbabwe, July 1990).

Table 1. Net revenue remaining after planting one hectare of oilseed crop and using the revenue to purchase maize meal foregone in selected semi-arid smallholder areas of Zimbabwe, calculated from equation (2).[a]

Smallholder Area		Net revenue (Z_i) for households that are:		% reduction in consumer price of maize meal for oilseed production/maize meal purchase strategy to break even
		Net grain sellers (D=1)	Net grain buyers (D=0)	
Buhera	groundnut	133	-11	4
	sunflower	80	-64	19
Chiruma	sunflower	26	-229	36
	groundnut	-96	-351	59
Mutoko	groundnut	550	337	b
	sunflower	133	-80	14
Nyajena	groundnut	221	138	b
	sunflower	79	-4	1
Zvishivane	sunflower	68	-160	21
	groundnut	19	-209	31

[a]Results are based on average cost, yield and price data collected from 276 households in semi-arid smallholder areas selected by MLARR (1990); [b]no decrease in maize meal consumer price is necessary because the strategy of oilseed production/maize meal purchase is already profitable, according to the survey data.

Source: calculated from equation (2) using crop budget data from MLARR (1990), milling cost and outturn data from Chisvo et al., and storage loss data from Giga.

Table 2. Characteristics of farm households in study sample, disaggregated by net grain sales quintiles.[a]

	Quintiles according to net grain sales (kgs/hh)					
	-2,503 to -378	-377 to -95	-94 to 278	279 to 1,289	1,290 to 13,286	Total sample
Number of households	127	125	127	123	126	628
family labor (adult equivalents)	8.34	6.45	6.12	6.92	7.90	7.16
draft animals	4.87	5.46	4.66	6.34	11.11	6.57
value of draft equipment (Z$)	981	911	1,035	1,347	1,597	1,177
fertilizer applied to grain crops (kgs/ha)	6.31	3.94	12.12	6.07	23.93	11.93
% households growing oilseeds with intention of selling	33	44	50	49	63	48
oilseed area (ha)	.30	.40	0.56	0.61	0.95	.55
grain area (ha)	1.77	1.94	1.85	2.03	3.07	2.13
total area planted (ha)	2.28	2.44	2.46	2.77	4.14	2.82
total area possessed (ha)	2.64	2.67	3.28	3.02	4.80	3.31
average grain yield (kgs/ha)	460	520	796	1,251	1,960	990
Main constraint to increasing area cultivated to grain (% of households identifying the following):						
not enough land:	37.4	24.3	16.8	22.7	14.3	23.1
draft power shortage:	27.0	29.5	25.7	16.8	12.5	22.3
labor shortage:	6.2	11.4	14.8	10.9	12.5	10.2
other crops more profitable:	4.2	3.4	14.4	17.2	24.2	12.5
total income per resident	176	164	230	303	317	237

[a]Net grain sales is defined as the quantity of grain sold via barter and cash minus the quantity of grain purchased via barter and cash.

Source: University of Zimbabwe/Michigan State University Food Security Project surveys (1990-91).

14

Table 3. Coefficient estimates for factors affecting hectares planted to oilseed crops.

Independent variables	Coefficients (t-statistics) for equation	
	(3)*	(4)
Constant	-.089 (-.420)	.007 (.042)
Adult equivalent labor (L)	-.076 (-1.64)	-.071 (-1.54)
Draft animals (DRAFT)	.052* (2.48)	.057* (2.72)
value of draft equipment (EQUIP)	3.80^{-4}** (3.72)	3.66^{-4}** (3.58)
Location 1 dummy (LOC$_1$)	.186 (1.31)	.150 (1.06)
Location 2 dummy (LOC$_2$)	.462 (1.69)	.421 (1.53)
Location 3 dummy (LOC$_3$)	1.24* (2.17)	1.32* (2.34)
Location 4 dummy (LOC$_4$)	1.49** (5.62)	1.45** (5.45)
Expected self-sufficiency level (SSL')[a]	-1.28^{-4} (-0.59)	1.34^{-4} (1.08)
Expected self-sufficiency dummy (D)	.012 (.115)	
Interaction term (SSL'*D)	2.09^{-4}* (2.27)	
Adjusted R-square:	.258	.249
Sum of squared errors:	241.02	244.80
Degrees of freedom:	483	485

*(**) : significant at the 5% (1%) level or lower.

[a] Predicted values of the variable. The instruments in equation (3-a) include all of the household asset and location variables shown here. The adjusted R-square and F-value of this regression were .27 and 23.05.

15

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