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# MARKET ACCESS BY SMALLHOLDER FARMERS IN MALAWI: IMPLICATIONS FOR TECHNOLOGY ADOPTION, AGRICULTURAL PRODUCTIVITY, AND CROP INCOME

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## ABSTRACT

In Malawi, maize is the major crop and food staple. Given limited off-farm employment opportunities, much-needed increases in household income for improving food security must come from gains in agricultural productivity through better technology and more profitable crops. In the past, agricultural policy promoted hybrid maize and, more recently, tobacco to increase smallholder income. This paper presents an analysis of what determines the adoption of these two crops and what kind of income effects follow from adoption. Apart from factor endowment and exposure to agroecological risks, differences in the household's access to financial and commodity markets significantly influence its cropping shares and farm income.

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## 1. INTRODUCTION

In Malawi, about three-quarters of smallholder acreage is planted to maize, mostly with low-yielding local varieties that may not even yield one metric ton per hectare. In the past decade, agricultural policy has emphasized hybrid maize—a capital-intensive, high-yielding technology—and, more recently, tobacco—a labor- and capital-intensive cash crop—as potential options for improving the income and food security of rural households in Malawi. This paper presents an analysis of the determinants of adoption of these two crops while focusing on access to commodity and financial markets and on income effects related to adoption. Recent policy changes in the agricultural sector in Malawi are described first. Next, the sampling procedure and data are presented. This is followed by the formulation of hypotheses about the determinants of adoption of hybrid maize and tobacco. The remaining sections discuss the model, its results, and policy conclusions.

## 2. RECENT AGRICULTURAL POLICY CHANGES

Past policies in Malawi by and large favored the production of high-value cash crops in the estate sector, while the smallholder sector was encouraged to produce and sell the country's food staple through official market channels (Mtawali 1993). During the 1980s and the early 1990s, agricultural credit, input, and extension policy focused on the dissemination of a fixed input package of hybrid maize and fertilizer that was delivered at subsidized interest rates and

input prices to smallholders. The massive distribution of maize credit to smallholders increased the share of higher-yielding hybrid maize in total smallholder hectarage planted to maize from about 8 percent in 1985 to a record high of 25 percent in 1992. The overall share of maize in smallholder acreage increased from 73 percent to 80 percent. However, the concentration of the loan portfolio to one drought-sensitive crop, combined with the droughts in 1992 and 1994 and political promises for writing off loan debt during the election year, led to widespread loan default and eventually to the collapse of the Smallholder Agricultural Credit Administration (SACA) parastatal in 1994. While 400,000 farmers received credit in 1992, 34,000 did so in 1994.

Following the major drought in 1992, the share of smallholder hectarage planted to nonmaize crops, cassava and pulses, in particular, temporarily increased. The response of farmers to the perceived advantages of drought-resistant crops, the sudden collapse of the public system for distributing credit for maize production, and the recent policy orientation towards diversifying smallholder crop production may all have played a role in this outcome. Following a second drought in 1993/94, large-scale distribution of free fertilizer and hybrid maize seed to drought-affected areas during 1994/95 and 1995/96 seems to have contributed to the recent revival of hybrid maize in smallholder farms, despite the unfavorable price policy for fertilized maize. While subsidies for credit and fertilizer were removed in 1994 and 1995, the output markets for maize and tobacco remain controlled. The Government of Malawi sets producer prices for maize below import parity level, and aims to stabilize consumer prices within a price band through open-market sales of domestic or imported maize.

The government has allocated an increasing share of tobacco quota to smallholders since 1990 (15 percent in 1995). The quota is offered to farmers who form a club. Members of tobacco clubs obtain improved access to extension, credit, and inputs while potentially realizing higher prices by selling directly to the auction floors. In addition to quota allocations issued through clubs, a large number of smallholders also grow tobacco to eventually sell to estates, which controlled all tobacco quota prior to reform. An intermediate buyer program was introduced in 1993 that allows smallholders to sell their tobacco to registered traders even if they are not members of clubs and are not allocated any production quotas. As a result of these policy changes, the number of smallholder households that produce tobacco has rapidly increased over the past five years.

## 3. SAMPLING DESIGN AND DATA

The data used are from 401 rural households in five districts of Malawi. The survey was conducted during 1995 by the International Food Policy Research Institute (IFPRI) in collaboration with the Department of Rural Development (DRD) of the Bunda College of Agriculture, University of Malawi. The survey was designed to analyze rural household access to and participation in four selected credit programs. The sample was therefore stratified along present and past program participation (Diagne, Zeller, and Mataya 1996). Two of the programs provide seasonal agricultural credit, mostly for tobacco and maize, one of them on a national scale. These are administered by the Malawi Rural Finance Company (MRFC) and the Malawi Union of Savings and Credit Cooperatives (MUSCCO). The other two programs

specialize in credit for off-farm enterprises, but operate only in a few districts. All programs work with member-based institutions at the village level, either groups or cooperative societies. MRFC members gain improved access to agricultural extension (mostly for hybrid maize and tobacco), and both agricultural credit programs give credit as agricultural inputs in-kind. We use mainly data from the agricultural module for the production years 1993/94 and 1994/95. The stratification of the households along participation in credit programs implies that simple descriptive means are not representative of the total population in the survey areas. To correct for this, the subsequent descriptive analysis uses sampling weights. We note, however, that the econometric analysis presented here does not account for the potential estimation bias that can arise from the choice-based sampling procedure.[1]

## 4. FACTORS INFLUENCING THE ADOPTION OF TECHNOLOGICAL INNOVATIONS

Feder, Just, and Zilberman (1985) conducted a comprehensive literature survey on adoption of agricultural innovations. They list factors that have been frequently identified as being influential in determining the adoption of an agricultural innovation. These include (1) farm size, (2) risk exposure and capacity to bear risks, (3) human capital, (4) labor availability, (5) credit constraint, (6) tenure, and (7) access to commodity markets. These factors are discussed below, in the Malawian context.

[1] This estimation procedure is the subject of ongoing work by one of the authors (see Diagne 1997).

In Table 1, we compare the mean and coefficient of variation for yields, gross revenue, input expenditures, and gross margins per hectare, by crop. The yield is valued at the quantity-weighted sample sales price. The table excludes the data from the district of Mangochi, where many households in both years experienced a complete maize crop failure. Despite having a mean yield of only 658 kilograms per hectare, that is, 49 percent below the yield of hybrid maize, the local maize varieties are grown in about half of the households. Several factors could explain this. The first factor is yield or income risk. In Table 1, the coefficients of variation for yield as well as for gross margins of hybrid maize are lower than those for local maize. However, when the data from the Mangochi District is included, the picture completely changes: on average for the whole sample, hybrid maize has lower yields and gross margins, but higher risk, than local maize. This suggests that hybrid maize does well in some agroclimatic regions, but exhibits negligible or no risk-adjusted advantages in areas less favorable for maize cultivation. The lower the risk-bearing ability of the household, the higher, therefore, could be its preference for local maize. As the ability to bear risks largely depends on the household's equity capital and access to credit, we hypothesize that the share of hybrid maize in total area planted increases with the access to credit and landholding of the household. Another reason for growing local maize varieties is their favorable food processing and on-farm storage characteristics compared to most, but not all, hybrid maize varieties (Smale, Heisey, and Leathers 1995). Maize breeding research has led to the release of new varieties that focus on improved drought resistance, on-farm processing, and storage characteristics.

**Table 1 Means and coefficient of variation for indicators of productivity and input intensity, by crop**

| Variable | Local Maize n =43 Mean | Local Maize n =43 Coefficient of Variation | Hybrid Maize n = 522 Mean | Hybrid Maize n = 522 Coefficient of Variation | Tobacco n= 121 Mean | Tobacco n= 121 Coefficient of Variation |
|---|---|---|---|---|---|---|
| | | (percent) | | (percent) | | (percent) |
| Yield (kilograms per hectare) | 658 | 58 | 1,289 | 54 | 746 | 112 |
| Gross revenue (MK) | 746 | 100 | 1,217 | 67 | 5,326 | 148 |
| Input expenditure(MK) | 101 | | 339 | | 595 | |
| Gross margin (MK) | 645 | 113 | 877 | 96 | 4,732 | 161 |
| Gross margin per unit of working capital | 6.4 | | 2.6 | | 8.0 | |

Source: Rural Finance Survey in Malawi, conducted by the Department of Rural Development, Bunda College of Agriculture, University of Malawi, and the International Food Policy Research Institute.

Note: All monetary values are in Malawi Kwacha (MK) and relate to 1 hectare, if not specified otherwise. The data have been weighted using the population strata from the village census. The data show means for two production years combined: 1993–94 and 1994–95. For most of the 100 survey households in the district of Mangochi, the maize crop, which consisted mostly of hybrid maize varieties, failed in both production years. In this district, 168 yield observations for hybrid maize and 25 yield observations for local maize were reported by the sample households, of which 70 percent and 52 percent were below 500 kilograms per hectare, respectively. The table shows means excluding the data for Mangochi. If included, the average gross margin per hectare of local maize is MK 627 and that for hybrid maize MK 491 for all households as an average, with coefficients of variation of 116 percent for local maize and 158 percent for hybrid maize.

The expenditures for inputs shown in Table 1 comprise direct costs arising from the acquisition of seed, organic and mineral fertilizer, pesticides, hired labor, transport, and marketing services. The expenditures per hectare are the lowest for local maize and highest for tobacco. Tobacco is not only the most labor-intensive crop, but also the most capital-intensive one. When capital is a binding constraint, the productivity of crops with respect to capital will influence the crop mix. As an average for both years, hybrid maize had by far the lowest capital productivity among the three crops. The gross margins in Table 1 indicate a considerable comparative advantage of tobacco over hybrid and local maize in utilizing the scarce factor of land and capital. On average, hybrid maize has a comparative advantage over local maize when land is the binding constraint, but loses out when access to capital is restricted. Capital constraints may also induce labor constraints, especially during the peak planting season, when family labor is not sufficient but households lack the liquidity to pay for hired labor.

Are there discernible patterns in factor endowment and other characteristics between households that specialize in local or hybrid maize or tobacco? Table 2 shows that mean gross margins per farm and per hectare are highest in the tobacco-growing households, and are generally lower in those households that grow local maize. A second pattern is that the shares of land planted with local maize or hybrid maize are lowest in the tobacco-growing households and highest in those households that grow both hybrid and local maize. Except for tobacco households, the shares of land planted to maize exceed 70 percent. Third, the amount of land possessed under formal title or customary

## Table 2 Means of socioeconomic characteristics of households, by cropping pattern

| Variable | Local maize only n =201 | Hybrid maize only n =254 | Hybrid and local maize n = 164 | Tobacco n = 121 | Mean n = 790 | Standard Deviation n = 790 |
|---|---|---|---|---|---|---|
| Gross margin (GMGTOT) | 837 | 1,378 | 1,171 | 3,664 | 1,283 | 2,785 |
| Gross margin per hectare of cultivated land (GMGTOTKA) | 748 | 1,193 | 721 | 1,764 | 935 | 1,158 |
| Share of area planted (%) to | | | | | | |
| local maize (SHCRLOCM) | 85.0 | 0 | 48.6 | 30.1 | 56.0 | 39.0 |
| hybrid maize (SHCRHYBM) | 0 | 71.1 | 38.5 | 38.4 | 24.6 | 33.1 |
| tobacco (SHCRTOBA) | 0 | 0 | 0 | 23.4 | 2.3 | 8.5 |
| Total land possessed (hectare) (LANDAREH) | 1.45 | 1.94 | 2.16 | 2.55 | 1.77 | 1.14 |
| Squared term of land possessed (SQLAND) | 2.61 | 6.22 | 5.90 | 8.30 | 4.45 | 12.91 |
| Unit value of agricultural land (MK per hectare) (PAGLAND) | 3,109 | 4,000 | 7,059 | 3,197 | 3,990 | 9,569 |
| Household size (HHSIZE) | 4.51 | 5.40 | 5.70 | 5.73 | 5.01 | 2.36 |
| Dependency ratio (DEPCHOLD) | 0.25 | 0.22 | 0.21 | 0.24 | 0.24 | 0.22 |
| Member of agricultural credit program (0=no, 1=yes) (MEMA) | 0.03 | 0.08 | 0.17 | 0.23 | 0.08 | .27 |
| Member of nonagricultural credit program (MEMN) | 0.02 | 0.04 | 0.03 | 0.07 | 0.27 | 0.16 |
| Characteristics of head: | | | | | | |
| Gender (0=female, 1= male) (MALEHEAD) | 0.56 | 0.74 | 0.69 | 0.92 | 0.66 | 0.48 |
| Age (years) (AGEH) | 46 | 40 | 46 | 43 | 44 | 15 |
| Years of formal schooling (YYEDUCH) | 2.4 | 4.0 | 3.1 | 3.8 | 3.0 | 2.7 |
| Distance to parents' home (km)(PHVKM) | 8.5 | 11.8 | 8.0 | 7.1 | 9.0 | 39.3 |
| Squared term of PHVKM (SQPHVKM) | 1,700 | 3,040 | 444 | 280 | 1,625 | 19,350 |
| Number of cattle possessed (NCATTL) | 0.2 | 0.5 | 0.6 | 0.8 | 0.4 | 1.7 |
| Number of small animals possessed (SMALANIM) | 2.5 | 7.5 | 5.6 | 6.3 | 4.4 | 6.5 |
| Dummy if household received hybrid maize seed as gift (1=yes, 0=no) (GSEEDHMZ) | 0 | 0.25 | 0.16 | 0.19 | 0.15 | 0.35 |
| Fertilizer price (MK per kilogram) PCFERT | 1.7 | 2.5 | 1.7 | 1.9 | 1.9 | 0.7 |
| Producer price for hybrid maize (MK/kg) (PPHMZ) | 0.9 | 1.0 | 0.9 | 1.0 | 1.0 | 0.3 |
| Producer price for tobacco (MK per kilogram) (PPTOB) | 6.9 | 8.6 | 6.5 | 7.8 | 7.2 | 5.2 |
| Consumer price for cassava (MK per kilogram) (PHCASVA) | 3.2 | 2.8 | 2.8 | 2.4 | 2.4 | 1.8 |
| Village-level characteristics: | | | | | | |
| Index of storage risks for grains (1=low, 3=high) (RISKSTOR) | 1.75 | 2.28 | 1.76 | 1.53 | 1.98 | 0.59 |
| Index of crop production risks (from 5 to 15) (CROPRISK) | 7.59 | 7.69 | 7.39 | 6.97 | 7.57 | 1.62 |
| Dummy, if poorer than neighboring villages (1=yes) (VPOORER) | 0.47 | 0.10 | 0.38 | 0.48 | 0.29 | 0.45 |
| Time and other costs for traveling to parastatal agricultural market outlet ( MK) (OPPCOST) | 10.9 | 2.8 | 4.9 | 0.8 | 5.8 | 11.8 |
| Coefficient of variation of rainfall (CVRYY) | 0.27 | 0.32 | 0.28 | 0.28 | 0.29 | 0.07 |
| District dummy Mangochi (MANGOCHI) | 0.03 | 0.72 | 0.09 | 0 | 0.35 | 0.48 |
| District dummy Nkota (NKOTA) | 0.04 | 0.13 | 0.05 | 0.16 | 0.09 | 0.29 |
| District dummy Rumphi (RUMPHI) | 0.03 | 0.01 | 0.20 | 0.28 | 0.06 | 0.23 |
| District dummy Dedza (DEDZA) | 0.64 | 0.04 | 0.36 | 0.09 | 0.29 | 0.46 |
| Dummy for production year (=1 if 1994/95) (YEAR95) | 0.49 | 0.51 | 0.39 | 0.67 | 0.50 | 0.50 |

Source: Rural Finance Survey in Malawi, conducted by the Department of Rural Development, Bunda College of Agriculture, University of Malawi, and the International Food Policy Research Institute.

Notes: Of the 790 observations from 401 households in both production years, 50 observations are from households that do not farm or do not grow tobacco or maize. For 12 of the 401 households, no crop production data are available for the production year 1994/95. The first three columns in the table refer to households that do not grow tobacco in a particular production year; they grow maize, besides other food crops. All monetary values are in Malawi Kwacha. The measure for area is hectare. The dependency ratio, DEPCHOLD, is computed as the sum of household members younger than 8 years or older than 64 years divided by household size. The effects of the drought during the production year 1993/94 varied considerably by district. The mean shares of area affected by maize crop failure were the following in each of the districts: Mangochi, 84 percent; Rumphi, 69 percent; Dedza, 64 percent; Nkhotakota, 56 percent; Dowa, 38 percent.

usufruct right is highest in the tobacco-growing households, and lowest in those households that only grow local maize. It is hypothesized that with higher land endowment, the relative importance of producing local maize for home consumption in case of remote or unreliable maize markets decreases. A fourth pattern in Table 2 is that households growing tobacco or hybrid maize seem to be better endowed in human capital, as reflected by the size of the household and the level of education of its head. In contrast, local maize-only producers score lowest in these indicators. Fifth, households in the latter group are headed more frequently by women. This suggests that female-headed households are less likely to adopt cash crops, an outcome that can be affected by a host of factors, such as the lack of access to credit or extension services and the time constraints resulting from farm and home production (Kumar 1994). Sixth, membership in an agricultural or nonagricultural credit program is lowest in the group of households that grow only local maize, and highest for tobacco growers. We hypothesize that program membership is important for the adoption of capital-intensive hybrid maize and tobacco. Finally, the costs of accessing agricultural input and output markets also seems to matter. As a measure of transaction costs in accessing markets, information was obtained about the time and transportation costs from the village to the nearest market outlet of the ADMARC, the parastatal marketing company. Those households growing only local maize incur the highest costs.

## 5. MODEL SPECIFICATION

Several authors have used recursive econometric models to explain the adoption of agricultural technology and cash crops and related income effects (Kumar 1994; von Braun, Puetz, and Webb 1989). A similar framework is applied in this paper. We conceptualize the adoption of hybrid maize and tobacco and the resulting income generation as a sequential decisionmaking process whereby previous cropping decisions predetermine income.

When crop technologies are divisible, as is the case for hybrid maize and tobacco, Feder, Just, and Zilberman (1985) suggest that the extent of adoption is best measured by the hectarage share of the crop under consideration. While participation in a credit program has been hypothesized as influencing the adoption of hybrid maize (Kumar 1994; Smale, Heisey, and Leathers 1995), past research rarely considered the potential simultaneity bias that arises from using the endogenous credit participation as a regressor in the adoption equation (Zeller et al. 1996). It is hypothesized here that the share, $S$, allocated to a particular crop is a function of a vector, $\mathbf{x}$, consisting of exogenous variables and endogenous credit program participation, $A$, such that

$$S = \alpha_2 \mathbf{x} + \gamma A + E_2. \tag{1}$$

The problem arises because unmeasured household-level variables affect both program participation, $A$, and cropping shares, $S$. With the resulting endogeneity, OLS regression of $S$

on participation in a credit program $A$ is likely to result in inconsistent estimates. For consistent estimation, a variant of the standard sample selection model is applied:

$$A^* = \alpha_1 v + E_1, \tag{2}$$

$$S = \alpha_2 \mathbf{x} + \gamma A + E_2, \tag{3}$$

where $A = 1$ if $A^* > 0$ and $A = 0$ otherwise.

The first equation states that $A$, access to a credit program, depends on a set of variables represented by **v**. The second equation states that adoption $S$ depends on another set of variables, **x**, and access to credit program $A$. The problem of simultaneity bias arises when equation (3) is estimated by OLS. This is because the random error terms, $E_1$ and $E_2$, are likely to be correlated, since unobserved household variables affect both $A$ and $S$. A two-stage procedure can be used to produce unbiased and consistent estimates of adoption, given that participation in a credit program is an endogenous variable (Maddala 1983). In the first stage, an estimate of $A$, $A^*$, is obtained by probit maximum likelihood method for equation (2). The predicted probability is then used in the second stage to obtain estimates of the cropping shares $S$ for local and hybrid maize and tobacco. In the second step of the recursive model, the effect of adoption of technology and new crops on farm gross margin is estimated, controlling for other factors, such as endowment in production factors, prices, predicted participation in credit programs, and transaction costs of accessing agricultural input and output markets. The dependent variable is the gross margin from the household's crop production in either of the

two production years. Means and standard deviations for the variables used in the regression models are found in Table 2.

## 6. INTERPRETATION OF MODEL RESULTS

In order to differentiate between the effects of nonagricultural credit programs and agricultural credit programs, two separate PROBIT models have been estimated (see first two columns of Table 3). It is assumed that the choices of participating in either of the programs are mutually independent. The regression results for cropping shares of hybrid maize, tobacco, and local maize, and those for crop income, are listed in the subsequent four columns of Table 3. Major results are highlighted next.

Participation in either of the two credit programs is modeled in a reduced form as an outcome of variables that either affect the supply side with the placement of programs or the demand side by asking for membership in such a program. The model seeks to account for endowment in physical, human, and social capital of households as well as agroecological risks. The probability of participation in both program types rises with increasing land possession (LANDAREH), but at a decreasing margin (SQLAND). The two coefficients for the indicators of the household's liquidity, the number of cattle (NCATTL) and that of small animals (SMALANIM), have the expected positive sign. Third, the coefficients for the indicators of human capital (AGEH for age and YYEDUCH for education of household head) and indicators of risk-bearing capacity (MALEHEAD for

**Table 3 Determinants of technology adoption and effects on smallholder crop income in Malawi**

| Regressand | Household participates in credit program: Nonagricultural | Household participates in credit program: Agricultural | Cropping shares for: Hybrid maize | Cropping shares for: Tobacco | Cropping shares for: Local maize | Income: Farm crop income |
|---|---|---|---|---|---|---|
| Constant | -3.418 | -3.309*** | 70.74*** | -1.71 | 34.4* | -2814.2*** |
| LANDAREH | 0.178** | 0.251*** | 0.19 | 1.21* | -2.44 | 995.8*** |
| SQLAND | -0.127* | -0.163* | 0.05 | -0.06* | 0.12 | -23.9 |
| PAGLAND | 0.109* | 0.478 | -0.000015 | -0.00003 | 0.00005 | 0.0063 |
| HHSIZE | 0.103*** | 0.276 | 0.76 | 0.59** | -1.35* | 10.0 |
| DEPCHOLD | -0.611** | 0.766*** | -9.62 | -1.95 | 18.3*** | 433.1 |
| MALEHEAD | -0.549*** | 0.369*** | -1.57 | -0.11 | 5.79* | |
| AGEH | 0.170 | 0.516 | | | | |
| YYEDUCH | 0.209 | -0.381 | 0.35 | 0.15 | -0.715* | 75.9 |
| PHVKM | 0.375** | -.524*** | | | | |
| SQPHVKM | -0.618** | 0.107*** | | | | |
| NCATTL | 0.034 | 0.695 | | | | |
| SMALANIM | 0.006 | 0.146 | | | | |
| GSEEDHMZ | | | 9.92*** | 1.32 | -8.45*** | |
| PCFERT | | | -4.26*** | -1.61*** | -7.00*** | -173.8 |
| PPHMZ | | | 0.85 | -4.37** | 5.54 | 953.9* |
| PPTOB | | | 0.03 | 0.393** | -0.38 | 382.1 |
| PHCASVA | | | 0.21 | -0.55*** | 0.84 | 112.0 |
| RISKSTOR | -0.456 | 1.436*** | -35.3** | 11.27*** | 13.95 | |
| CROPRISK | -0.693 | 0.189*** | -10.9*** | 2.05*** | 7.52** | |
| VPOORER | -2.298 | -0.315 | 35.0 | -22.88*** | 6.91 | |
| OPPCOST | | | -1.17** | 0.69 | -0.52 | -4.4 |
| MANGOCHI | 4.706 | -3.850*** | 186.6*** | -51.31*** | -96.3 | -4,126** |
| NKOTA | 4.335 | -3.558*** | 133.6** | -38.73*** | -81.6 | -2,877* |
| RUMPHI | 4.048 | 3.248*** | 118.5** | -35.56*** | -50.3 | -1,375 |
| DEDZA | 1.810 | 1.950*** | 89.8* | -47.13*** | -6.48 | 783 |
| CVRYY | 0.132 | -1.428** | 47.88*** | 7.84 | -48.3 | |
| YEAR95 | | | 4.25 | 2.82 | -2.09 | -2,132* |
| PCMEMA[a] | | | 38.25** | 9.75* | -56.9** | -470 |
| PCMEMN[a] | | | -23.90 | 2.73 | 32.19** | 2,155 |
| PSHYBM[a] | | | | | | 6.21 |
| PSTOBA[a] | | | | | | 191.55** |
| PSLOCM[a] | | | | | | -25.78* |
| Adjusted $R^2$ | 36.9 | 38.7 | 43.6 | 18.9 | 32.6 | 26.2 |

[a] Predicted values of MEMA, MEMN, SHCRHYBM, SHCRTOBA, and SHCRLOCM. *, **, and *** are significant at the 10, 5, and 1 percent levels, respectively.

gender of household head and DEPCHOLD for dependency ratio) have the expected signs, except for education affecting participation in agricultural credit programs. The distance in kilometers to the home of the head's parents (PHVKM), and its squared term (SQPHVKM), are used as indicators of possession of social capital. It is hypothesized that individuals that live in the same village as their parents or close to their parents have more friends and relatives who can help them get accepted into a group or help them in retaining program membership in times of financial difficulties. For the agricultural credit programs, the coefficients for the distance and the squared term carry the expected signs, and are highly significant. However, lower social capital implies a higher probability for joining a nonagricultural credit program. This result is explained by the fact that both the nonagricultural programs explicitly target poorer, often female-headed households. Finally, the household's exposure to agroecological risks is expected to affect participation in credit programs. Three variables capture different risk types. The index variable RISKSTOR indicates the degree of risk in obtaining losses while storing food. The index variable CROPRISK reflects the degree of exposure to five different types of crop risks (flooding, drought, hail, insects and other pests, and river bank erosion). The variable CVRYY measures the coefficient of variation in rainfall for the area in which the household resides. We hypothesize that an increase in both storage and crop production risks increases the probability of households applying for membership in a credit program. On the other hand, credit programs may be less inclined to accept members in risk-prone communities because of higher probability of loan default. As a result of the hypothesized divergent demand and supply effects, the expected signs are undetermined. The regression finds that more storage and crop production risks significantly increase the

probability of being a member of an agricultural credit. Furthermore, an increasing interannual variation in rainfall significantly reduces the probability of participation in an agricultural credit program. While the first two effects seem to be driven by demand, the latter appears to be a result of supply. The agricultural credit program may shy away from areas with known rainfall risk.

As for determinants of cropping shares, we highlight major similarities and differences for the three crops. A first robust result is that larger farms will have a higher cropping share of hybrid maize and tobacco and less of local maize. Moreover, households with more members, with less dependents, or with better educated heads, will grow more of hybrid maize and tobacco and less of local maize. Concerning participation in formal credit markets, the coefficients for predicted membership in agricultural credit programs (PCMEMA) carry an expected and significant sign for all three crops. Increasing the probability of participation by an absolute 10 percent raises the cropping share of tobacco by an absolute amount of 0.97 percent and that for hybrid maize by 3.82 percent, while it reduces that for local maize by 5.64 percent. The effect of nonagricultural programs (PCMEMN) on cropping shares for hybrid and local maize is opposite from that of agricultural credit programs. Here, members significantly increase their share of local maize and grow less of hybrid maize. We explain this as follows. First, the in-kind delivery of loans in agricultural credit programs induces transaction costs for converting the loan to other uses, as households have to sell their maize inputs. Hence, a bias towards hybrid maize production is created. Second, agricultural credit programs focus their extension and other activities on hybrid maize and tobacco. Nonagricultural credit programs, on the other hand, disburse the credit in cash, but lend for off-

farm enterprise development. Third, households have a limited risk-bearing capacity. Members in nonagricultural credit programs already take additional risks in their off-farm enterprises, so they seek to reduce their risk exposure in the on-farm enterprises by substituting local for hybrid maize and other crops. This interpretation is further supported by results related to the variables measuring on-farm food storage and crop production risks. Households that live in villages with high levels of food (maize) storage and high crop production risks are predicted to plant considerably less of hybrid maize. Furthermore, transaction costs (OPPCOST) in accessing agricultural markets significantly matter for the cropping decision. The model shows that with higher travel costs to the nearest parastatal agricultural market outlet, the share of hybrid maize declines.

For the cropping shares of all three crops, rising fertilizer prices have a negative effect. Compared to other major crops grown by smallholders, such as cassava and beans, not only hybrid maize and tobacco, but also local maize can be fertilizer-intensive. On average for the sample as a whole and for the production years 1993/94 and 1994/95, the farmgate price ratio of maize to fertilizer is roughly 0.5 (as can be seen from Table 2). The recent policy changes have considerably worsened this ratio. An evaluation of national fertilizer trials for maize found that at 1996/97 price levels, it is not profitable to apply fertilizer on hybrid maize in most areas of the country (Benson 1997). Finally, the government's distribution of free maize seed during 1994/95 (GSEEDHMZ) had a significant positive effect in increasing the share planted to hybrid maize.

In Column 6 of Table 3, we show the results for the income effects of changing cropping shares. The regression function controls for the household's endowment in land and its quality

(PAGLAND) and in human capital, and measures the income effects of predicted cropping shares for hybrid and local maize as well as tobacco. Crop income significantly increases with higher land endowment, but with a decreasing effect at the margin, and with higher household size and education of the household head. Both the cropping share for hybrid maize (PSHYBM) and tobacco (PSTOBA) increase the crop income, with tobacco having a relatively large and hybrid maize a very small positive effect. Expanding the share of local maize (PSLOCM) has a negative effect. Yet, the estimated income gains from expanding the cropping share of hybrid maize at the expense of local maize are negligible when compared to the gains that can be realized when growing tobacco. The recent rapid expansion of tobacco production among smallholders in those areas where tobacco can be grown is, therefore, explained by the results. From the regression results, it can be computed that increasing the probability of membership in an agricultural credit program by an absolute 10 percent increases crop income by MK 311 despite a negative direct effect of MK 47, which is presumably caused by opportunity costs of time and other costs of participating in a credit club that requires regular meetings. The large indirect income effect of MK 358 is caused through increased shares of more profitable hybrid maize (+MK 24) and tobacco (+MK 187) and the reduction of local maize (+MK 147).

## 7. POLICY CONCLUSIONS

Several conclusions regarding the impact of alternative food policy instruments are deduced from the analysis. First, the granting of a tobacco production quota to smallholders has provided smallholders with the opportunity to grow a new and profitable cash crop. The resulting rapid adoption of tobacco as a new crop is not the outcome of technology innovation, but of policy reform and related institutional changes in the tobacco subsector. Second, we find that households with small farm sizes and low risk-bearing ability are able to adopt capital-intensive crops, such as hybrid maize and tobacco, if policies improve their access to credit, extension, input, and output markets. Participation in an agricultural credit program has been found to substantially raise the cropping share for hybrid maize and tobacco, and membership in both credit program types has a sizable effect on crop income. We therefore conclude that an expansion of the existing credit programs could have beneficial effects on agricultural production of smallholders and rural incomes, but that the public costs of an expansion must be weighted against these benefits. Third, participation in agricultural credit programs is found to be lower for households that live in areas with higher variation in rainfall. This is likely to be a result of supply-side effects. Agricultural credit programs seem to shy away from these areas because of higher expected loan default. In order to better serve risk-prone areas, the credit programs may introduce member-financed and pooled emergency funds for covering covariate risks of loan defaults, or charge higher interest rates to cover the risk. Fourth, we find that a household's transaction costs in accessing the nearest parastatal market outlet for agricultural inputs and outputs have a negative influence on the share of area cropped with hybrid maize.

This finding supports our conclusion that access to agricultural markets and related improvements in rural infrastructure and marketing institutions are essential for adoption of new technology and transformation of subsistence-oriented smallholder agriculture. Fifth, the speed and success of this transformation will also depend on getting prices right. The results show that cropping shares and, therefore, supply response are sensitive to changes in product and fertilizer prices. The current policy in favor of net buyers of maize should be seen as a hindrance to increased maize production. Combined with the removal of subsidies for fertilizer and credit, and the significant recent devaluation of the Malawi Kwacha, hybrid maize has lost much of its relative profitability over local maize and other calorie-rich food crops. In fact, maize as such has lost profitability, and the recent expansion in production in cassava, tobacco, and other crops is an outcome of this development. Under the current policy setting and population growth rate, food imports are therefore likely to become an ever-increasing fiscal burden. Other policy instruments that have the potential to more efficiently provide a safety net for the urban and rural poor should be explored and tested in order to eventually end the disincentives for smallholder maize production.

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