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Can Crop Purchase Programs Reduce Poverty and Improve Welfare in Rural Communities? Evidence from the Food Reserve Agency in Zambia

Winnie Fung
Harvard University

Lenis Saweda O. Liverpool-Tasie
Michigan State University

Nicole Mason
Michigan State University

Ruth Uwaifo Oyelere
Morehouse College

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Winnie Fung
Wheaton College

Nicole Mason
Michigan State University

Saweda Liverpool-Tasie
Michigan State University

Ruth Uwaifo Oyelere
Emory University and IZA

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IZA

P.O. Box 7240
53072 Bonn
Germany

Phone: +49-228-3894-0
Fax: +49-228-3894-180
E-mail: iza@iza.org

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ABSTRACT

Can Crop Purchase Programs Reduce Poverty and Improve Welfare in Rural Communities? Evidence from the Food Reserve Agency in Zambia

The last decade has seen a resurgence of parastatal crop marketing institutions in sub-Saharan Africa, many of which cite improving food security and incomes as key goals. However, there is limited empirical evidence on the welfare effects of these programs. This article considers one such program, the Zambian Food Reserve Agency (FRA), which purchases maize from smallholder farmers at a pan-territorial price that typically exceeds maize market prices in surplus production areas. Using both fixed effects and an instrumental variables approach combined with correlated random effects, we estimate the effects of the FRA's maize marketing activities on smallholder farm household welfare. Results suggest that FRA activities have positive direct welfare effects on the small minority of smallholder households that are able to sell to it. However, the results also suggest negative indirect FRA effects, as higher levels of FRA activity in a district are associated with higher levels of poverty.

JEL Classification: Q12, Q13, Q18, I38, D31, O13

Keywords: crop marketing boards, strategic grain reserves, maize, smallholder farmers, income, poverty, Zambia, sub-Saharan Africa

Corresponding author:

Ruth Uwaifo Oyelere
Emory University
Department of Economics
Rich Memorial Building
Atlanta, GA 30322-2240
USA
E-mail: ruth.oyelere@emory.edu

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NON-TECHNICAL SUMMARY

In recent years, marketing boards have again become commonplace in eastern and southern Africa. The recent rise in crop marketing boards can be linked to the potential of these agencies in addressing key challenges of smallholder farmer access to output markets and price stability for producers and consumers. Despite their proliferation, there is limited empirical evidence as to how the activities of these marketing boards are affecting crop markets and even less on the welfare effects of these programs. This paper begins to fill this gap by empirically estimating the effects of the activities of the Zambian Food Reserve Agency (FRA) on the economic well-being of smallholder farmers. The FRA is a parastatal grain marketing board/strategic food reserve. Its goal is to ensure national food security and stabilize crop prices by maintaining a national strategic food reserve.

The authors find that despite FRA's core value of wealth creation for farmers and its being one of the Zambian government's two flagship agricultural sector Poverty Reduction Programs, its effects on smallholder welfare are mixed. Specifically the results suggest that FRA activities have positive direct effects on the small minority of smallholder households that are able to sell to it. However, the results also suggest negative indirect FRA effects, as higher levels of FRA activity in a district are associated with higher levels of poverty. This research adds to the growing literature that highlights the unintended negative consequences of well-intended program interventions in developing countries.

Introduction

Historically, agricultural policies and crop marketing institutions in developed countries[1] tended to subsidize farmers at the expense of urban consumers, whereas such policies and institutions in developing countries often taxed farmers[2] to the benefit of urban consumers (Barrett and Mutambatsere 2005). Following the push for government exit from private markets that accompanied structural adjustment policies in the 1980s and 1990s, numerous government or parastatal crop marketing boards throughout the developing world were completely dismantled or had their activities markedly scaled back. However, in recent years, increasing attention is being paid to the potential for crop marketing boards to address key challenges of smallholder access to output markets and price stability for producers and consumers (Jayne, Myers, and Nyoro 2008; Chapoto and Jayne 2009; Jayne, Chapoto, and Govereh 2010; Mason and Myers 2013; Mason, Jayne, and Myers 2015). Though now sometimes restricted to the management of strategic grain reserves or insurance against extraordinary price fluctuations, such marketing boards have again become commonplace in eastern and southern Africa (ibid.). However, there is limited empirical evidence about how the activities of these marketing boards are affecting crop markets and even less on the welfare effects of these programs.

This article begins to fill this gap by empirically estimating the effects of the activities of the Zambian Food Reserve Agency (FRA) on the economic well-being of smallholder farmers.[3] The FRA, a parastatal grain marketing board/strategic food reserve, was established by the Food Reserve Act of 1995. The FRA's goal is to ensure national food security and stabilize crop prices by maintaining a national strategic food reserve

(FRA n.d.). FRA's crop marketing activities have focused almost exclusively on maize, and the Agency is the country's dominant buyer of maize in most years (table 1). It purchases maize from farmers at its depots throughout rural Zambia at a pan-territorial price that is typically higher than the wholesale private sector price in major maize-producing areas (Govereh, Jayne, and Chapoto 2008; Chapoto and Jayne 2009; Mason and Myers 2013; Mason, Jayne, and Myers 2015). It then stores the maize, exports it or sells it on the domestic market at potentially below-market prices (mainly to select large-scale millers to be ground into maize meal, and occasionally to traders or the general public) (ibid.).

Although selling to FRA at above-market prices has the potential to increase farmer incomes and improve their food security, FRA activities could also have unintended, negative effects on Zambian producers and consumers, particularly those who are not able to sell to FRA. For example, FRA's pricing and buying/selling activities are rarely announced in advance, and when they are, pronouncements are rarely respected. This creates a great deal of uncertainty in Zambian maize markets and discourages involvement by traders and other private sector actors at various levels of the maize value chain (Sitko and Kuteya 2013). Furthermore, FRA's maize marketing activities tend to siphon maize out of rural markets and concentrate it at main FRA depots in the district, provincial, and national capitals; this puts upward pressure on private sector wholesale and retail maize prices to the benefit of maize net sellers but to the detriment of rural maize net buyers and urban consumers (Mason and Myers 2013; Sitko and Kuteya 2013).[4] The concentration of maize at FRA depots also means that less grain

is circulating in rural and urban markets, making it difficult for consumers to source grain and mill it into maize meal at hammermills – typically a more affordable option than buying maize meal produced in large-scale commercial mills (Mason and Jayne 2009; Sitko and Kuteya 2013). Moreover, analysis by Mason and Myers (2013) suggests that FRA activities stabilized maize prices between 1996 and 2008, but that this price stabilization is likely to have mainly benefited large-scale farmers.

Only a small minority of smallholders sells maize to the FRA (e.g., 10% of all smallholders in 2007/08 and 27% in 2011/12), and these tend to be wealthier households with more land (Mason, Jayne, and Myers 2015; see also table 2). Although such farmers may earn higher incomes from these sales due to the above-market prices typically offered by the Agency, given their already elevated wealth status, this may have little or no impact on rural poverty rates, which have remained near 80% since the FRA was established (Mason, Jayne, and Myers 2015).[5] Moreover, given the myriad of potential unintended consequences of FRA operations, the net welfare effects of FRA activities on Zambian smallholders are difficult to predict *a priori.* This is despite FRA's core value of wealth creation for farmers and its being one of the Zambian government's two flagship agricultural sector Poverty Reduction Programs (FRA n.d.).[6]

This paper contributes to the literature in three main ways. First, it adds to the thin knowledge base on the effects of the FRA and similar post-structural adjustment crop marketing boards on the welfare of African smallholders. While several studies have considered the effects of these agencies on maize market prices (Jayne, Myers, and Nyoro 2008; Mason and Myers 2013) or smallholder crop production patterns (Mather

and Jayne 2011; Mason, Jayne, and Myers 2015), to the best of our knowledge, only Mghenyi, Myers, and Jayne (2011) and Mather and Jayne (2011) have quantified the effects of these programs on rural households' economic well-being. Mghenyi, Myers, and Jayne (2011) estimate the welfare effects of a large, discrete maize price increase in Kenya on rural income and poverty. They attribute this price increase to the Kenyan National Cereals and Produce Board (NCPB) but do not directly estimate the welfare effects of changes in the level of NCPB activities. Mather and Jayne (2011), also studying the case of Kenya, estimate the impacts of the NCPB on rural net crop income. While they find positive effects of NCPB activities during the *previous* season on current season net crop income, they do not consider the effects of *current* season NCPB activities, nor do they investigate the effects of the NCPB on total household income, poverty, or other welfare indicators.

The second contribution of this paper is that it is the first to econometrically estimate the effects of the Zambian FRA on smallholder incomes and poverty. While previous studies have speculated about the welfare effects of the FRA based on other empirical findings, none have explicitly estimated the welfare effects of the FRA. For example, Mason and Myers (2013) estimate the effects of the FRA on maize market prices, and discuss the likely distributional effects of the higher and more stable prices brought about by FRA activities. Mason, Jayne, and Myers (2015) estimate the effects of FRA's purchase quantities and prices on smallholder area planted with maize versus other crops, as well as crop yields and quantities harvested. They find that an increase in the lagged FRA farm gate price raises smallholders' maize price expectations, which

induces a maize production response through area expansion (extensification) but not through increased yields (intensification). They find no evidence of statistically significant FRA effects on the production of other crops. Their estimates suggest that the maize supply response is very small and mainly among relatively better-off smallholders with more land. They argue that FRA activities are therefore unlikely to have major impacts on rural poverty, although they do not test this directly. Sitko and Kuteya (2013) contend that the FRA's maize marketing activities are likely responsible for the paradox of higher maize prices in Zambia in recent years despite consecutive bumper maize harvests, and discuss the likely distributional effects. Though relevant, none of these studies explicitly estimates the welfare effects of the FRA.

The third contribution of this article is that it estimates both the direct effects of a household's own sales to the FRA on its welfare, as well as the indirect effects of greater FRA activity in a district on the welfare of households in that district. Previous studies focus mainly on the direct effects, but given the discussion above, there are several indirect pathways through which FRA activities could positively or negatively affect smallholder welfare. It is possible that the indirect effects of the FRA could be larger than its direct effects. In addition given our findings, this article adds to the growing literature that highlights the unintended negative consequences of well-intended program interventions in developing countries.

To estimate the direct and indirect effects of the FRA on the incomes and poverty status of Zambian smallholders, we use household panel survey data spanning years before and during the scale-up of FRA activities, and exploit household- and district-level

differences in maize sales to the FRA.[7] We use both a fixed effects (FE) approach and an instrumental variables (IV) approach combined with correlated random effects to control for time invariant heterogeneity and correct for the potential endogeneity of household-level sales to the FRA. Our results suggest that FRA activities have positive *direct* effects on households that sell to it. However, the results also suggest negative *indirect* FRA effects on smallholder welfare: an increase in district-level maize purchases by the FRA is associated with higher poverty incidence, gap and severity. We explore the pathways through which these effects occur.

The remainder of the article is organized as follows. In the next section, we briefly describe the data used in the analysis. We then present the conceptual model, the empirical approach and results. We conclude with a discussion of the policy implications of these results.

Data

The data are drawn mainly from the Zambia Supplemental Survey to the 1999/2000 Post-Harvest Survey (SS), a nationally representative, three-wave longitudinal survey of smallholder farm households implemented by the Central Statistical Office (CSO), Ministry of Agriculture and Cooperatives (MACO), and the Food Security Research Project (FSRP) in mid-2001, 2004, and 2008. The SS covers the 1999/2000, 2002/03, and 2006/07 agricultural years (October-September) and the subsequent crop marketing years (May-April of 2000/01, 2003/04, and 2007/08).[8] The SS contains detailed information on household demographics, crop production and sales, livestock activities, income from all

on- and off-farm sources, and other socio-economic factors. Of the 6,922 households interviewed in the first wave of the SS, 5,358 (77%) were interviewed in the second wave; and of those, 4,286 (80%) were interviewed in the third wave. The balanced panel therefore consists of 4,286 households and 12,858 observations (4,286 households times three survey waves). Given attrition between survey waves, there is the potential for attrition bias, so we test for it using the regression-based approach described in Wooldridge (2010, p. 837). We fail to reject the null hypothesis of no attrition bias ($p>0.34$) for all dependent variables used in the article. For more information on the SS data, attrition rates, and sampling design see Megill (2005) and Mason, Jayne, and Myers (2015).

We supplement the SS data with information from FRA administrative records on district-level maize purchases by the Agency each crop marketing year; geo-referenced rainfall data from the Tropical Applications of Meteorology using SATellite data (TAMSAT) (Milford and Dugdale 1990; Grimes, Pardo-Igúzquiza, and Bonifacio 1999; Maidment et al. 2014; Tarnavsky et al. 2014); and crop prices from CSO/MACO Post-Harvest Surveys for 1998/99, 2001/02 and 2005/06.

Conceptual Framework

Rural Zambia, like most parts of rural SSA, is characterized by imperfect credit and labor markets as well as poor infrastructure. Consequently, our conceptual framework is based

on the well-established prototype of the agricultural household farm with imperfectly functioning markets (Singh, Squire, and Strauss 1986; Sadoulet and de Janvry 1995; Bardhan and Udry 1999). Following Otsuka, Cordova, and David (1992) we assume that the agricultural household solves a constrained utility maximization problem by allocating its resources such as land to crop production, household labor time to various farm and non-farm income earning activities and capital inputs to various productive activities. The household faces budget, time and endowment constraints and is subject to the relevant crop production functions. The solution to this constrained utility maximization problem yields a reduced form for household income as a function of factor prices ($\boldsymbol{w}$) and product prices in expectation as of planting time ($\boldsymbol{p^e}$), household labor supply ($\boldsymbol{l}$) and land ($\boldsymbol{A}$) as well as other household characteristics ($\boldsymbol{z}$) such as non-land assets, variables that are likely to affect the household's production environment, shocks likely to affect income and other socio-demographic variables.[9] Consequently, the reduced form of household income can be expressed as follows:

$$y = f(\boldsymbol{w}, \boldsymbol{p^e}, \boldsymbol{A}, \boldsymbol{l}, \boldsymbol{z}) \quad (1)$$

In this article, we consider both the direct and indirect effects of household maize sales to and purchases by the FRA on household income. A household's income can be directly affected through its sale of maize to the FRA. The intensity of FRA activity in a household's district of residence could also indirectly affect the household's income through various channels.[10] For example, an increase in maize purchases at above-market prices by the FRA in a district could put upward pressure on private sector maize prices in the district (Mason and Myers 2013). Thus, holding maize production constant, an

increase in household farm income could come through increased sales to FRA or through an increase in the price farmers receive for maize sold to private sector buyers.[11]

It is also possible that an increase in FRA activity could result in lower private sector prices for maize and/or other crops, resulting in lower household incomes. FRA activity has been shown to raise farmers' maize price expectations and stimulate a maize production response (Mason, Jayne, and Myers 2015). If there is not a concomitant increase in maize demand, then private sector maize prices could actually fall in regions with higher FRA activity.[12] Furthermore, if intense FRA activity crowds out some private crop traders (who are unable to compete with the FRA on price and may be involved in trading maize and other crops), then reduced competition and increased market power among the remaining traders could result in lower prices being paid to smallholder farmers for maize and/or other crops. On the demand side, increased maize production in response to FRA activities could increase household maize supply for home consumption and reduce the demand for other staples that are substitutes in consumption. This could also lower the price of these other staples, potentially resulting in lower household incomes. Thus, while we expect the direct effect of the FRA on household income to be positive (because the household is being paid a higher price for its maize), both positive and negative indirect FRA effects on household income are plausible. Whether the net indirect effect of FRA activity is positive or negative is ultimately an empirical question.

To capture the potential direct and indirect effects of the FRA on household welfare in rural Zambia, we add two additional right-hand-side variables to equation (1):

$$y = f(\boldsymbol{w}, \boldsymbol{p^e}, \boldsymbol{A}, \boldsymbol{l}, \boldsymbol{z}, FRA_D, FRA_I) \quad (2)$$

FRA_D is intended to capture the direct effect and FRA_I captures the (net) indirect effect of FRA activities on household welfare. The empirical specifications of these variables are discussed in the next section.

Following equation (2) above, the effects of FRA on other welfare indicators determined by income can also be explored. We are primarily concerned with whether FRA improves farmers' incomes and reduces poverty in rural Zambia. Our income measures capture the various crop and non-crop income sources available to farmers, and our poverty measures are based on the traditional Foster-Greer-Thorbecke (FGT) poverty measures (Foster, Greer, and Thorbecke 1984).

Empirical Strategy

We empirically estimate the effects of FRA's maize purchase program on smallholder farmer incomes and poverty by exploiting the panel nature of the dataset. Equation (3) represents the basic empirical model:

$$y_{it} = \propto_i + \beta_1 FRA_{D_{it}} + \beta_2 FRA_{I_{it}} + \boldsymbol{\rho}\boldsymbol{x}_{it} + \mu_t + \varepsilon_{it} \quad (3)$$

where y_{it} is a measure of welfare for household *i* in year *t*; FRA_{Dit} and FRA_{Iit} are the direct and indirect measures of a households exposure to FRA activities. $\boldsymbol{x}_{it}$ is a vector of other regressors that affect household welfare (more details below); $\propto_i$ are time-invariant household-specific effects; μ_t are year fixed effects; ε_{it} is the idiosyncratic error term; and β_1, β_2 and $\boldsymbol{\rho}$ are parameters to be estimated.

We measure a household's participation in FRA's maize purchase program, the direct effect (FRA_{Dit}) in two ways: (i) a binary variable equal to one if a household sold

any maize to FRA in a particular year, and equal to zero otherwise; and (ii) the quantity (in kg) of maize sold by the household to FRA. The net indirect effects of the FRA (As discussed further below, we use panel data methods (the fixed effects estimator and the correlated random effects approach) to control for the time-invariant heterogeneity ($\propto_i$) that affects household welfare and that could be correlated and the other covariates in equation ().

Broadly speaking, $\boldsymbol{x}_{it}$ includes the determinants of household crop production and income per equation (2) above. Specifically, x includes expected producer prices for the main crops marketed by Zambian smallholders — maize, groundnuts, beans, and sweet potatoes (proxied by producer prices at the previous harvest); factor prices including the commercial price of inorganic fertilizer and an agricultural wage rate (the median wage to weed 0.25 ha of land in the household's standard enumeration area, SEA);[13] the education of the household head, a dummy variable equal to one if the household head is male and zero otherwise, the number of household members in different age categories (under 5, aged 5 to 14, aged 15 to 59, aged 60 and above), household landholding size, and household farm assets (value of farm equipment and livestock at the beginning of the periods for which income is measured). To account for location-specific factors likely to affect households' agricultural output and livelihood opportunities, we include various geographic variables at the district or SEA level: the number of moisture stress periods in an SEA in (agricultural) year *t* and the average number of moisture stress periods over the last 16 years;[14] growing season rainfall in the SEA in year *t* and in each of the last three years (*t-1*, *t-2*, and *t-3*), and the mean and coefficient of variation of growing season

rainfall over the last 16 years; and the percentage of households in the district earning income from non-farm salaried/wage employment, from formal/informal business activities, and from work on others' farms to proxy for the off-farm income-generating opportunities available to the household. In addition, we control for household-level shocks that could affect production and welfare — namely, the prime-age death of the male household head/spouse, the female household head/spouse, and other male or female household members in the last three to four years.[15]

In addition to subsidizing maize *output* prices through FRA activities, the Zambian government has a major maize *input* subsidy program that provides inorganic fertilizer and hybrid maize seed to smallholder farmers at below-market prices. To account for the effects of that program, we could include as a covariate the amounts of government-subsidized fertilizer and seed acquired by the household. However, these variables are likely to be endogenous to household welfare. Given that the welfare effects of the input subsidy program are not the focus of the current article (and are explored in detail in Mason and Tembo (2015)), and given these endogeneity concerns, we instead include in the regressions a more aggregated, district-level variable to control for the effects of the input subsidy program. More specifically, we include in the regressions the administratively determined quantity of government-subsidized fertilizer allocated to the household's district (in MT per agricultural household).[16] This variable is unlikely to be endogenous to the individual household after controlling for the other observed covariates and time invariant heterogeneity. Table 3 presents basic summary statistics for all variables used in the analysis.

As mentioned above, y_{it} is a measure of household welfare. We consider several household welfare indicators: real gross income, real gross income per capita, poverty incidence, poverty gap, and poverty severity. Total gross income includes crop income, livestock and fish-farming income, and off-farm income (from remittances, formal/informal business activities, salaried/wage employment, and pensions). Crop income is maize income plus income from other crops. Maize income is defined as the kg of maize sold to the FRA multiplied by the pan-territorial FRA price, plus the kg of maize produced but not sold to the FRA multiplied by the district-median private sector producer price of maize. Other crop income is defined as the gross value of crop production (kg of each crop produced multiplied by the provincial median crop price at the producer level).[17] Real per capita income is real gross income divided by the number of household members. Poverty incidence is a binary variable that equals one if household income falls below the US$1.25/capita/day poverty line, and zero otherwise.[18] The poverty gap is defined as the proportional difference between household income and the poverty line for households with income below the poverty line, and set to zero for households with income above the poverty line. Poverty severity is the square of the poverty gap (Foster, Greer, and Thorbecke 1984).

Our main method of identification of the effects of FRA participation on household welfare is based on a fixed effects (FE) approach. The FE method attenuates potential biases that can threaten our ability to consistently estimate the causal effects of FRA participation by using variation in maize sales to the FRA within a household over time to identify the effect of FRA. However, although the FE approach controls for time

invariant unobserved heterogeneity that may be correlated with both FRA participation and household welfare, the FE approach does not deal with endogeneity caused by time-*varying* unobserved heterogeneity. While we have controlled for numerous time-varying observables in the model, we cannot rule out the possibility that such time-varying unobservables still exist.

To deal with the possible existence of time-varying unobservables that are correlated with both maize sales to FRA and household welfare, we also estimate an instrumental variables (IV) model for each measure of household welfare. We instrument for maize sales to the FRA using distance from the homestead to the nearest FRA depot. This distance was only collected in the 2008 survey wave. Given that we cannot instrument for maize sales to FRA in the 2001 and 2004 survey waves, we cannot use all three waves of data and estimate fixed effects instrumental variables (FE-IV) regressions. However, we can take advantage of the panel information on the other exogenous variables and combine the IV approach with a correlated random effects (CRE) approach to control for time invariant unobserved heterogeneity (Wooldridge 2010).[19] This entails including in the IV regressions for 2008 the household-specific time averages (across the three survey waves) of the time-varying exogenous explanatory variables. In other words, the 'IV-with-CRE' models are estimated using observations on the dependent variables, sales to the FRA, IV, and exogenous explanatory variables as of the 2008 survey wave, along with the household time averages of the exogenous explanatory variables.

Our argument for the validity of the IV is as follows. The locations of FRA depots are administratively determined and are beyond the control of individual households.

While it is relatively obvious that our instrument is relevant, it is possible to argue that our instrument does not satisfy the exclusion restriction because the location of the FRA depots is not random. Although we do not claim that the locations of the FRA depots are random or that our instrument is *unconditionally* exogenous, we believe it meets the exogeneity criteria *conditional* on the controls we have highlighted above and *conditional* on controlling for time invariant unobserved heterogeneity via CRE. This means that conditional on the observed covariates and the time invariant heterogeneity, distance from the homestead to the nearest FRA depot should not be correlated with any time-varying unobservables that are correlated with our dependent variables. It is possible, for example, that distance to the nearest FRA depot is correlated with the economic development of an area or with an area's suitability for growing maize. These variables may also be correlated with our dependent variables and render the instrument invalid if not accounted for. However, we control for these factors via CRE and by including district-level fixed effects in the IV regressions as well as by including variables capturing the off-farm income-generating opportunities in the household's district. It is therefore plausible to assume that our IV-with-CRE estimates of the effects of the FRA on household welfare are consistent.

Results

The results for our base model are presented in tables 4 to 7. Tables 4 and 5 present the FE estimates, while tables 6 and 7 present the IV-with-CRE estimates. Throughout the remainder of the article, we refer to the latter simply as the IV estimates. Tables 4 and 6

use the binary variable (sold to FRA) as our measure of FRA participation, whiles tables 5 and 7 capture FRA participation with the kilograms of maize sold to FRA by the household. Columns (1)-(5) in each table highlight the estimated effects of FRA on the various welfare indicators: (1) gross household income, (2) per capita income, (3) poverty incidence, (4) poverty gap, and (5) poverty severity. For brevity, we focus our discussion of the results on the estimated impacts of FRA participation (as opposed to the effects of other covariates).[20]

Tables 4 and 5 indicate that direct participation in FRA's maize purchase program has large, positive and statistically significant effects on farm household welfare. Households that sold to the FRA had higher total and per capita incomes as well as lower probability of household income falling below the poverty line, smaller poverty gap, and less severe poverty, than did other households (table 4). Selling to FRA reduces poverty incidence by about 8 percentage points, and the poverty gap and poverty severity by approximately 14 and 15 percentage points, respectively.[21] Table 5 indicates that increases in the quantity of maize sold to the FRA also had positive welfare effects. The effect of an additional kilogram of maize sold to the FRA on total household income (1,775 ZMK/kg in real 2008 ZMK terms) is almost two and a half times the price offered by the FRA in 2007/08 (760 ZMK/kg per table 1). As expected, the per-kg effects of maize sold to the FRA on poverty incidence, gap, and severity are quite small (-0.0018, -0.0013 and -0.0010 percentage points, respectively). But if we multiply these coefficients by the sample mean of 2,731 kg of maize sold to FRA (among those who sold to FRA, from table 3), we see that at the sample mean selling to FRA reduced poverty incidence,

gap, and severity by approximately 4.9, 3.6, and 2.7 percentage points, respectively. These estimates are smaller than the estimated effects of the binary indicator for selling to FRA in table 4, and reflect modest reductions in the poverty metrics given sample mean poverty incidence, gap, and severity levels of 90%, 66%, and 53%, respectively.

The results also reveal that more intense FRA activity in a district has the indirect effect of reducing per capita household income (table 5) and increasing the poverty incidence, gap and severity (tables 4 and 5). These effects are statistically significant (at the 10% level or lower) and quite large in magnitude. For example, table 5 shows that the negative, indirect effect on per capita income of a one-kg per agricultural household increase in district-level sales to the FRA (-232 ZMK) is 1.8 times larger than the positive, direct effect of a one-kg increase in household maize sales to the FRA (130 ZMK). Similarly, the poverty incidence, gap, and severity-increasing indirect effects of a one-kg increase in district-level sales to the FRA are 2.5 to 4.8 times larger than the poverty-reducing direct effects of household maize sales to the FRA. In other words, while direct sales to the FRA increase household welfare, the FE results suggest that FRA activities have indirect effects that are welfare-reducing for smallholder farmers in rural Zambia. The magnitude of the welfare-reducing indirect effects appears to exceed the welfare-increasing direct effects by a considerable margin. Below we explore potential mechanisms for these effects.

The results from the IV estimation are presented in tables 6 and 7. The top portion of each of these tables shows the key parameter estimate from the first stage of the IV estimation: the effect of the instrument (distance to the nearest FRA depot) on FRA

participation. The full regression results for the first stage associated with tables 6 and 7 are reported in table A1 in the appendix. The first stage results indicate that the distance to the nearest FRA depot is highly partially correlated with the decision to sell to the FRA and quantity sold to FRA (table A1 in the appendix). The instrument passes basic weak instrument tests.[22] The IV results in Tables 6 and 7 generally support our findings in tables 4 and 5. They confirm that where significant, direct FRA participation improves household welfare. Even after controlling for any potential endogeneity of household-level maize sales to the FRA, such sales still positively affect household total and per capita income, and reduce poverty incidence, poverty gap and poverty severity. The main difference between the FE and IV results is that both the direct effect of FRA participation and the indirect effects of district-level FRA activity on poverty incidence are no longer statistically significant in the IV estimation.[23] However, for the poverty incidence regressions, Durbin-Wu-Hausman tests fail to reject the null that selling to FRA and quantity of maize sold to FRA are exogenous. Therefore in the poverty incidence cases, the FE estimates are preferred to the IV estimates.[24] Overall, the results in tables 4 through 7 suggest that while directly selling to FRA leads to improvement in smallholder welfare, households living in a district with higher levels of FRA activity may face unintended, negative consequences. Specifically we find that higher levels of FRA activity in a district are associated with an increase in poverty incidence, gap, and severity among smallholder households in that district. [25]

Next we explore some potential mechanisms through which FRA participation affects the welfare of households. These results (FE and IV estimates) are presented in

tables 8 and 9, respectively, and show the effects of FRA participation on income from different sources (maize income, non-maize crop income, agricultural wage income, and other income).[26] The FE results in table 8 indicate that selling to the FRA significantly increases maize income (as expected) while having no direct effect on non-maize crop income and agricultural wage income. In contrast, an increase in FRA activities in a district on average leads to a decline in non-maize crop income. The IV results in table 9 in most cases suggest no significant effects from participation or quantity sold to FRA apart from results summarized in columns (4) and (5). Based on the Durbin-Wu-Hausman test on each specification in table 9, we fail to reject the null hypothesis that FRA participation is exogenous in the maize income, non-maize crop income, and agricultural wage income estimations. Hence our FE estimates in table 8 are preferred for the results summarized in columns (1)-(3) and (5)-(7).

Our inference from tables 8 and 9 can be summed up as follows. Direct FRA participation increases maize income of participants but has little or no effect on other sources of income. Higher FRA activity in a district, however, leads to a decline in non-maize crop income. The indirect FRA effect of reducing non-maize crop income of households in the district provides a potential channel through which FRA activity increases poverty incidence, gap, and severity of households in the district per tables 4 through 7.

Empirical evidence suggests that the negative FRA indirect effect on non-maize crop income comes mainly through lower non-maize crop prices as opposed to lower output of non-maize crops.[27] Mason, Jayne, and Myers (2015) find no evidence of

statistically significant FRA effects on the production of non-maize crops; moreover, simple regressions of provincial-level non-maize crop prices on provincial-level maize purchases by FRA suggest that higher levels of FRA activity are associated with lower non-maize crop prices, particularly rice. Higher levels of FRA activity could result in lower non-maize crop prices due to FRA crowding out private crop traders. If there were fewer traders coming into rural areas to buy maize and other crops, the few remaining traders would likely have more market power and the scope to pay farmers lower prices for their crops. There is some evidence of lower crop trading activity as a result of the FRA and other similar programs (Chapoto and Jayne 2011; Sitko and Jayne 2014). For example, Chapoto and Jayne (2011) find that the mean number of traders visiting Zambian villages declined with increased government intervention in the maize market. Lower prices for non-maize crops could also be driven by lower demand for these crops due to higher maize production and consequent supply for home consumption. If maize production is stimulated due to FRA price incentives in districts with higher levels of FRA activity, this could increase maize supplies for home consumption and reduce demand for other staples, putting downward pressure on the prices for other staples.

To further unpack the potential channels through which FRA activity affects non-maize crop income, in tables 10 and 11 we present FE and IV estimates of direct and indirect FRA effects on income from several non-maize crop groups: other staples, high value food crops, and cash crops.[28] More precisely, we measure effects on the gross value of production of these crop groups. The FE specifications (which are preferred over the IV based on the Durbin-Wu-Hausman tests) indicate that where significant, selling to

FRA and having more FRA activity in your district both reduce the gross value of other staples produced by the household. Thus, based on table 10, it appears that the negative indirect effect of FRA activity in the district on non-maize crop income (per table 8) is mainly driven by negative effects on the gross value of production of other staples. Again, results from Mason, Jayne, and Myers (2015) suggest no FRA effects on the production of other crops, so the negative FRA effect on the gross value of other staples appears to come mainly through negative FRA effects on other crop prices, particularly the price of rice, which is an important substitute for maize in Zambia.

Our results indicate that one potential channel through which higher FRA activities in a district increase poverty incidence, gap and severity is through depressing prices for other staples, resulting in lower income from other staples, and lower non-maize crop income more generally. This decline in income could lead to increases in poverty incidence, gap, and severity. Wealthier households (e.g., those with more land, farm equipment, or livestock) are more likely to be able to sell to FRA (see table 2 and table A1 in the appendix). In contrast, poorer households are less able to produce a marketable surplus and sell to FRA and thus benefit little from direct participation in FRA. Poorer households also appear to be more likely to bear the negative externalities of the program as evidenced by negative indirect FRA effects on the poverty metrics but generally not on total income or per capita income on average across all households. In general, the results suggest that households that are able to sell to the FRA experience a welfare increase, while on average households in districts with greater FRA activity experience a welfare decline.

Thus far we have focused on income-based measures of household welfare. To conclude the analysis we explore whether FRA participation affects a non-income-based measure of welfare: household calorie availability per adult equivalent (AE) per day.[29] The FE and IV results in tables 12 and 13, respectively, indicate that selling to FRA and the quantity sold to FRA do not have a significant effect on a household's calories available per AE per day. However, the FE model (which is the preferred specification based on the Durbin-Wu-Hausman tests) indicates that more intense FRA activity in a district has a negative effect on calories available per AE per day. Thus, we find some evidence that greater FRA purchases in a household's district not only exacerbate poverty, but that it also reduces a non-income-based welfare measure: calorie availability. The negative indirect effects of the FRA on calorie availability could be due, *inter alia*, to its negative effects on per capita incomes of the poor (households have less money to purchase food); its price-increasing effects on wholesale and retail maize prices (making it more expensive for households to purchase food) (Mason and Myers 2013; Sitko and Kuteya 2013); and its negative effects on maize availability in rural and urban markets as grain is concentrated at FRA main depots (Sitko and Kuteya 2013).

Conclusion and Policy Implications

Over the last two decades, there has been a renewed interest among African policymakers in using crop purchase programs to raise incomes and reduce poverty among smallholder farmers in east and southern Africa. However, to date, there is very limited empirical evidence on the welfare effects of these programs. This article used household panel data

and both fixed effects and instrumental variables approaches to estimate the smallholder farm household welfare effects of one such program: the Zambian Food Reserve Agency (FRA). The results suggest that, other factors constant, on average FRA activities have large, positive direct welfare effects on smallholder households that sell maize to the Agency, but even larger negative indirect welfare effects on smallholder households in districts where the FRA purchases more maize. Consequently, the results indicate that the benefits of FRA participation for smallholders are restricted to those who actually sell to the Agency, and that smallholder households that are not able to sell to the FRA may actually be harmed by its activities. Despite nearly 20 years of FRA involvement in maize marketing and with nearly 50% of Zambia's agricultural sector Poverty Reduction Program expenditures devoted to the FRA each year (MFNP, various years), rural poverty rates in Zambia have remained near 80% (CSO, 2009, 2011). Furthermore, the welfare-reducing indirect effects of the FRA call into question its viability as a poverty reduction tool.

Although reallocation of funds currently spent on the FRA to other poverty alleviation programs or investments may be more cost-effective at improving smallholder welfare, FRA activities are highly politicized and ending FRA participation in maize marketing in Zambia is unlikely to be politically feasible. Thus, it is useful to consider how FRA's maize purchase program might be modified to improve its impacts on smallholder farmers' welfare. Although further research is needed on this topic, some potential modifications related to the findings of this article are as follows.

First, our results indicate that those households that are able to sell to the FRA experience sizeable improvements in welfare. Yet relatively few smallholder households (e.g., 10% in 2007/08 and 27% in 2011/12) actually sell to the FRA, and these tend to be households with more land. Reducing the barriers to FRA participation by smallholders could improve the distributional effects of the program. Many smallholder households do not sell to the FRA because they do not produce a marketable surplus. For example, in 2011/12, which was a bumper maize harvest year, only 42% of Zambian smallholders were net sellers of maize; the remaining 58% were either maize autarkic (30%) or net buyers (28%) (CSO/MAL/IAPRI 2012). Raising smallholder productivity so that more households are able to produce a marketable surplus of maize could open up the possibility of selling to the FRA to more households, even holding constant the total quantity of maize purchased by the Agency.

Second, reducing the transactions costs associated with selling to the FRA could also make it a more viable option for smallholder farmers. Poorer households that produce enough to sell to the FRA may be discouraged from doing so due to the frequent long and uncertain delays between when farmers deliver their maize to the FRA and when they receive payment. For example, in 2011/12, farmers were paid for only 23% of their sales transactions to the FRA within one month of delivery; the median time to payment was two months, and the 75th and 90th percentiles were three and four months, respectively (CSO/MAL/IAPRI 2012). While wealthier households may be able to wait months to be paid, this is much more difficult for poorer, cash-constrained households. Encouraging smallholders with small marketable surpluses to bulk their product with

others before selling to the FRA might also help to reduce the transactions costs experienced by individual farmers.

Third, our results coupled with those of Chapoto and Jayne (2011) and Sitko and Jayne (2014) suggest that FRA maize purchase activities are likely reducing private sector trading activity for maize and other crops. While further analysis is needed to identify the causal effects of the FRA on private trading activity, it may be possible to modify FRA's purchase modalities to crowd in the private sector. One option would be reverting back to FRA's initial approach of purchasing maize through private traders (at market prices) rather than setting up its own buying depots (Mason and Myers 2013).[30] Purchasing maize through the Zambia Agricultural Commodities Exchange (ZAMACE) is another possibility. A third option to consider is focusing FRA purchases on relatively remote areas where the private sector is not actively engaged in crop trading.

Finally, government investment in rural infrastructure and market information systems could help to improve smallholders' access to markets and increase their bargaining power and the farmgate prices they receive for their crops. Our findings indicate that careful consideration of these and other options to raise farmer incomes and reduce poverty are necessary. Despite its goals of securing Zambia's national food reserve and taking wealth to rural Zambia, FRA's direct participation in maize marketing may be doing more harm than good to the vast majority of Zambian smallholders.

Notes

[1] These marketing agencies were usually very specialized in scope and scale.

[2] They taxed agriculture with over-valued exchange rates or price fixing (on export crops) or by fixing consumer prices below market prices for food crops (Barrett and Mutambatsere 2005).

[3] In Zambia, smallholders are defined as farm households that cultivate less than 20 hectares of land.

[4] The majority of Zambian smallholders are maize net buyers or maize autarkic. For example, in 2007/08, an average to slightly above average maize production year, 49% were net buyers, 23% neither bought nor sold maize (i.e., were autarkic), and 28% were net sellers. In 2011/12, a bumper maize harvest year, 28% were net buyers, 30% were autarkic, and 42% were net sellers (Mason, Jayne, and Myers 2012).

[5] The official rural poverty rate in Zambia was 83% in 1998, 78% in 2004, 80% in 2006, and 78% in 2010, the last year for which official rural poverty rates have been released (CSO, 2009, 2011). These poverty rates are based on the national poverty line and are consumption/expenditure-based. In this article, our poverty measures are based on the US$1.25/capita/day poverty line, are income-based, and are for smallholder farmers, not the broader rural population.

[6] The second is the Farmer Input Support Program (FISP), a targeted hybrid maize seed and fertilizer subsidy program. Between 2004 and 2011, the FRA and FISP each accounted for an average of roughly 30% of total agricultural sector spending and 48% of agricultural sector Poverty Reduction Program spending (Mason, Jayne, and Myers 2015).

[7] The panel data cover the 2000/01, 2003/04, and 2007/08 marketing years. Per table 1 and Mason, Jayne, and Myers (2015), FRA purchased no maize from smallholders in 2000/01 due to funding shortfalls. Its maize purchases in 2003/04 and 2007/08 were equivalent to 21% and 74% of smallholders' maize sales, respectively.

[8] The FRA did not purchase maize domestically during the 2000/01 marketing year; it purchased maize in 36 of 72 districts in 2003/04, and expanded its buying presence to 58 of 72 districts by 2007/08.

[9] Mason and Tembo (2015) use a similar conceptual framework in their study of the effects of Zambia's input subsidy program on smallholder welfare.

[10] Henceforth we refer to an increase in the level of maize purchases by the FRA in a district as an increase in 'FRA activity'. We focus on the district level because this is the most disaggregated level at which administrative data on total FRA purchases are available.

[11] An increase in maize purchases by the FRA would shift the private sector supply curve to the left, *ceteris paribus* (Mason and Myers 2013). Even if the private sector maize price (e.g., the price offered by private traders) is lower than the FRA price, farmers might choose to sell to the private trader to avoid some of the transactions costs associated with selling to FRA. For example, whereas private traders typically pay cash at the time of sale, it takes weeks if not months for farmers to be paid by the FRA, and farmers often need to spend hours waiting in line at FRA depots to deliver their maize.

[12] FRA activity could also affect household incomes by affecting the production of other crops; however, Mason, Jayne, and Myers (2015) find no evidence of such effects.

[13] SEAs are the most disaggregated geographic unit in the data set and contain approximately 150-200 households or two to four villages.

[14] Moisture stress periods are defined as the number of 20-day periods with less than 40 mm of rainfall during the November-March growing season.

[15] Prime-age is defined as 15-59 years old in this article.

[16] Subsidized fertilizer and seed are allocated in fixed proportions at the district level, so it is not necessary to include the district-level allocations of both subsidized fertilizer and seed.

[17] Non-maize crops are much less frequently marketed than maize, so there are not enough sales price observations on non-maize crops to compute district median producer prices; provincial median prices are used instead.

[18] The US$1.25/capita/day poverty line is calculated based on the 2005 purchasing power parity exchange rate for Zambian Kwacha (ZMK) to US dollars, inflated or deflated to the survey years using the consumer price index.

[19] Both the FE approach and the CRE approach (also known as the Mundlak-Chamberlain device) require the assumption of strict exogeneity of the explanatory variables conditional on the time invariant heterogeneity to be consistent. In addition to this assumption, the CRE approach requires the assumption that the time invariant unobserved heterogeneity is a function of the time-averages of the time-varying explanatory variables in the model. See Wooldridge (2010) for further details on the FE estimator and the CRE approach.

[20] The full regression results are reported for tables 4 and A1 only. Due to the large number of regressions, for other tables we report only the key parameter estimates of interest. Full regressions results for other tables are available from the authors upon request.

[21] In addition to the linear fixed effects results for poverty incidence presented in table 4, we also estimated CRE probit models for this binary dependent variable. The poverty incidence results are robust to our choice of estimator.

[22] Table 16 shows the F-stat and p-value for the test of the significance of the instrument. Though the F-stat only satisfies Staiger and Stock (1997) rule of thumb of F greater than 10 for the sell to FRA specification, this rule is more relevant when testing the joint significance of multiple instruments. In our case we have only one instrument and, the size and significance of the instruments estimate in the first stage suffices. In our case this estimate is large which suggests that the instrument is not weak. Moreover in both our sell to FRA and quantity sold to FRA specifications, we can reject the null that the instrument is not significant in the first stage given the p-value in the F test.

[23] Since the IV results are based on the 2008 SS data only, we do not emphasize differences in magnitude between the FE and IV estimates.

[24] For the other specifications, we reject the null hypothesis that selling to FRA and the quantity of maize sold to FRA are exogenous, indicating that the IV specification is preferred over FE.

[25] We also run all our estimations using the log values of income and values of production and our results are largely maintained. Some of these results are presented in

tables A2 and A3 in the Appendix. We also ran all our estimations on winsorized values of our continuous dependent variables to ensure our results were not being driven by outliers. Rather than dropping extreme values, winsorizing replaces extreme or outliers beyond a specific percentile with the value observed at that percentile. The main results in the paper are robust to the use of winsorized values.

[26] Agricultural wage income is total agricultural off-farm wage income (both cash and in-kind). Other income is total income minus all crop income and agricultural wage income.

[27] To confirm that these negative results are not driven by the fact that higher FRA activity likely occurs in areas with high potential for maize production and thus less likely to be producing other staples, we also ran all regressions using data only from the main maize producing areas and our results are maintained.

[28] Other staples are sorghum, rice, millet, Irish potato, sweet potato, and cassava. High value crops are groundnuts, mixed beans, bambara nuts, cowpeas, velvet beans, kenaf, and cashew. And cash crops are sunflower, soybeans, seed cotton, Virginia tobacco, burley tobacco, coffee, paprika, and popcorn.

[29] Calorie availability is estimated as the calories from own crop production that is retained (and not sold), calories from purchased staple foods (the surveys did not capture purchases of non-staples), and calories from retained own production of milk and eggs. See Wineman (2013) for details.

[30] This is how the FRA purchased maize in 1996/97 and 1997/98.

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TABLES

Table 1. FRA Maize Pan-territorial Purchase Prices and Quantities, 1996/97-2014/15 Marketing Years

Marketing year	FRA pan-territorial purchase price (ZMK/kg)[a]	FRA domestic maize purchases (MT)	FRA purchases as % of small-holder maize sales
1996/1997	236	10,500	3.7
1997/1998	157.6	4,989	2.4
1998/1999	N/A	0	0
1999/2000	N/A	0	0
2000/2001	N/A	0	0
2001/2002	N/A	0	0
2002/2003	800[b]	23,535	16.4
2003/2004	600	54,847	21.0
2004/2005	720	105,279	31.8
2005/2006	720	78,667	51.9
2006/2007	760	389,510	85.7
2007/2008	760	396,450	74.3
2008/2009	900[c]	73,876	14.2
2009/2010	1300	198,630	32.4
2010/2011	1300	883,036	83.1
2011/2012	1300	1,751,660	122.5
2012/2013	1300	1,045,895	72.6
2013/2014	1300[d]	426,454	35.1
2014/2015	1500[d]	1,031,303	29.6

Note: [a]Prices in 1996/97 and 1997/98 are averages across districts where the FRA was active. [b]Initial price of K600 raised to K800 in Aug. 2002. [c]Increased to K1,100 in Sep. 2008. N/A = Not applicable. FRA was not buying in 1998/99 through 2001/02 so there was no FRA pan-territorial price in those years. [d]As of January 1, 2013, Zambia rebased its currency by dividing the old currency (ZMK) levels by 1,000. The new currency is called ZMW. Values reported above are all in old currency (ZMK) units.
Source: Mason, Jayne, and Myers (2015); FRA; CSO/MACO Crop Forecast & Post-Harvest Surveys.

Table 2. Maize Sales to the FRA by Smallholder Farm Households by Landholding Size Category, 2007/08 marketing year

Landholding size category	% of smallholder HHs	% of HHs in category selling to FRA	Mean kg of maize sold to FRA		Category % of total maize sold to FRA by smallholders
			All HHs	HHs selling to FRA	
0-0.99 ha	30.3	2.2	11	529	1.3
1-1.99 ha	34.8	7.6	79	1,040	10.2
2-4.99 ha	28.3	16.1	339	2,109	35.8
5+ ha	6.5	28.4	2,161	7,608	52.7
All HHs	100.0	9.7	268	2,764	100.0

Source: Authors' calculations using data from the 2008 CSO/MACO/FSRP Zambia Supplemental Surveys.

Table 3. Summary Statistics

Variable	N	Mean	Std. Dev.	Min	Max
Dependent variables					
Gross household income (ZMK)	12858	4949863	18300000	0	1240000000
Per capita income (ZMK)	12858	787567	2315816	0	137000000
Poverty incidence (1=poor)	12858	0.90	0.30	0	1
Poverty gap	12858	0.66	0.31	0	1
Poverty severity	12858	0.53	0.32	0	1
Maize income (ZMK)	12858	1168465	3399894	0	154000000
Non-maize crop income (ZMK)	12858	788284	1665414	0	180000000
Agricultural wage income (ZMK)	12858	69527	561386	0	18000000
Other income (ZMK)	12858	2923588	17300000	-2	1240000000
Calories availability per person per day	12858	3402.7	4323.3	0	187688.7
Conditional on selling to FRA:					
Gross household income (ZMK)	520	13900000	24800000	688116	265000000
Per capita income (ZMK)	520	1707809	2936618	98302	32700000
Poverty incidence (1=poor)	520	0.72	0.45	0	1
Poverty gap	520	0.40	0.32	0	0.94
Poverty severity	520	0.26	0.25	0	0.88
Maize income (ZMK)	520	5610817	8745122	304000	116000000
Non-maize crop income (ZMK)	520	1198865	3011456	0	51000000
Agricultural wage income (ZMK)	520	37748	361547	0	6840000
Other income (ZMK)	520	7071049	19100000	-0.25	245000000
Calories availability per person per day	520	4417	4266	80	53501
Main explanatory variables					
Sold to FRA (=1)	12858	0.035	0.184	0	1
Quantity of maize sold to FRA (kg), including zeroes	12858	95.35	1060.05	0	70000
Quantity of maize sold to FRA (kg), excluding zeroes	520	2731.32	5003.32	50	70000
Normalized district-level maize sales to FRA (kg/agric. HH)	12858	108.60	210.13	0	3440.10
Instrumental variable					
Distance from homestead to nearest FRA depot (km)	4286	22.88	32.65	0	222.5
Control variables					
Maize producer price, district median t-1 (ZMK/kg)	12858	475	181	179	1043
Groundnut producer price, provincial median t-1 (ZMK/kg)	12858	1199	369	652	2000
Mixed beans producer price, provincial median t-1 (ZMK/kg)	12858	1166	321	667	2167
Sweet potato producer price, provincial median t-1	12858	229	109	100	478

(ZMK/kg)					
District commercial fertilizer price (ZMK/kg)	12858	2023	283	1083	2828
District wage for weeding (ZMK)	12858	41.0	14.5	15	131.9
Education of household head (years)	12854	5.03	3.70	0	19
Male-headed household (=1)	12858	0.77	0.42	0	1
Number of children under 5	12858	0.81	0.94	0	12
Number of children aged 5 to 14	12858	2.02	1.65	0	19
Number of prime age adults (aged 15 to 59)	12858	3.02	1.79	0	22
Number of adults aged 60 and above	12858	0.38	0.63	0	4
Landholding size (ha)	12858	2.12	2.81	0	234.05
Value of farm equipment (ZMK)	12858	212756	731141	0	26600000
Value of livestock (ZMK)	12858	1779884	8236531	0	571000000
Number of moisture stress periods	12858	1.66	1.13	0	5
Long run mean moisture stress periods	12858	2.02	0.78	0	4.13
Growing season rainfall (mm)	12858	845	111	547	1222
Growing season rainfall in t-1(mm)	12858	854	133	475	1215
Growing season rainfall in t-2 (mm)	12858	895	147	477	1284
Growing season rainfall in t-3 (mm)	12858	862	103	592	1272
Long run mean rainfall (mm)	12858	817	94	558	1108
Long run rainfall coefficient of variation (%)	12858	15.2	3.3	8.6	24.5
% of households in district earning non-farm income	12858	13.4	7.3	0	51.4
% of households in district earning business income	12858	34.1	15.4	3.8	90.4
% of households in district earning income from other farms	12858	9.0	9.2	0	72.6
Disease-related prime-age (PA) death of male head/spouse	12858	0.008	0.092	0	1
Disease-related PA death of female head/spouse	12858	0.013	0.114	0	1
Disease-related PA death of other male household member	12858	0.037	0.190	0	1
Disease-related PA death of other female household member	12858	0.043	0.202	0	1
Amount of government fertilizer distributed in district (MT/hh)	12858	0.036	0.037	0	0.725
Number of provinces = 9					
Number of districts = 70					
Number of survey waves = 3					
Number of households in balanced panel = 4286					

Note: All ZMK values are in real 2008 terms.
Source: Authors' calculations using data from the 2001, 2004, and 2008 CSO/MACO/FSRP Zambia Supplemental Surveys.

Table 4. Effects of Selling to the FRA on Household Income and Poverty (Fixed Effects Estimates)

	(1)	(2)	(3)	(4)	(5)
Dependent variable:	**Gross income**	**Per capita income**	**Poverty**	**Poverty gap**	**Poverty**
Explanatory variables	(ZMK)	(ZMK)	**incidence**		**severity**
Sold to FRA (=1)	4286816.108***	323,097.140*	-0.080***	-0.135***	-0.152***
	(1174774.552)	(164,886.974)	(0.028)	(0.021)	(0.019)
District maize sales to FRA	-1,256.457	-235.783	0.0000500**	0.0000640***	0.0000672***
(kg per agricultural HH)	(1,189.535)	(146.165)	(0.0000238)	(0.0000239)	(0.0000254)
Number of children under 5	158,761.009	-122,122.809***	0.017***	0.029***	0.032***
	(362,748.263)	(36,673.542)	(0.005)	(0.004)	(0.005)
Number of children aged 5	218,660.586*	-59,353.600***	0.008***	0.0170***	0.019***
to 14	(124,362.027)	(15,590.957)	(0.003)	(0.002)	(0.003)
Number of prime age adults	712,560.285**	48,337.808	-0.005	-0.004	-0.005*
(aged 15 to 59)	(324,106.983)	(35,507.456)	(0.003)	(0.003)	(0.003)
Number of adults aged 60	437,032.627	7,755.901	0.006	0.002	0.001
and above	(343,733.536)	(43,222.802)	(0.008)	(0.009)	(0.010)
Education of household	85,664.430	13,023.206	-0.003*	-0.006***	-0.007***
head	(85,654.537)	(11,637.266)	(0.002)	(0.002)	(0.002)
Male-headed household	123,919.284	63,521.319	-0.010	-0.046**	-0.055***
(=1)	(493,013.942)	(66,923.950)	(0.017)	(0.018)	(0.019)
District wage for	-36,768.410	-5,135.626	0.0004	-0.0006	-0.0008*
weeding	(35,419.192)	(4,331.649)	(0.0005)	(0.0005)	(0.0005)
% of households in district	49,641.252	8,828.758*	-0.002**	-0.0006	-0.0003
earning non-farm income	(40,746.000)	(5,158.743)	(0.0008)	(0.0007)	(0.0008)
% of households in district	44,734.517***	5,437.980***	-0.0007	-0.003***	-0.003***
earning business income	(15,159.799)	(2,091.109)	(0.0004)	(0.0004)	(0.0004)
% of households earning	-63,536.134	-7,512.181	0.0002	0.001*	0.001**
income from other farms	(55,789.610)	(6,577.638)	(0.0005)	(0.0005)	(0.0006)
District commercial	-2,733.285	-344.308	0.00001	0.00003*	0.00003**
fertilizer price	(2,234.256)	(252.828)	(0.00002)	(0.00002)	(0.00002)
Amount of gov't fertilizer	-5733535.650	-803,243.581	0.096	0.107	0.103
distributed in district	(4164357.447)	(607,657.626)	(0.112)	(0.109)	(0.111)
Maize producer price, t-1	2,638.827	508.516	-0.00004	-0.00003	-0.00001
	(3,700.281)	(489.716)	(0.00005)	(0.00005)	(0.00005)
Groundnut producer price,	-2,477.360	-302.931	0.00001	0.00004	0.00005
t-1	(1,605.239)	(207.143)	(0.00004)	(0.00003)	(0.00003)
Mixed beans producer price,	2,526.301	169.012	0.00005	-0.00004	-0.00009**
t-1	(2,119.110)	(260.993)	(0.00004)	(0.00004)	(0.00004)
Sweet potato producer	-3,214.931	-524.806	0.0001	0.0001	0.00009
price, t-1	(4,044.827)	(566.664)	(0.00008)	(0.00008)	(0.00008)
Growing season rainfall	-601.312	166.848	-0.00007	-0.0002***	-0.0003***
	(4,209.619)	(548.514)	(0.00006)	(0.00005)	(0.00005)
Growing season rainfall, t-1	-50.460	-177.668	0.00002	-0.000003	0.000009
	(2,541.044)	(399.769)	(0.00006)	(0.00006)	(0.00006)
Growing season rainfall, t-2	3,273.731	200.841	0.0001	0.00005	0.00005
	(4,547.220)	(561.698)	(0.00006)	(0.00005)	(0.00006)
Growing season rainfall, t-3	-4,133.081	-574.837	-0.00003	-0.0002***	-0.0002***
	(4,497.951)	(551.750)	(0.00006)	(0.00006)	(0.00007)
Long run mean rainfall	27,450.611	4,160.878	0.00005	-0.0004	-0.0004
	(23,247.745)	(3,037.257)	(0.0006)	(0.0005)	(0.0006)
Number of moisture stress	-467,646.976	-44,119.112	0.002	-0.006	-0.008
periods	(532,589.825)	(62,961.170)	(0.006)	(0.005)	(0.005)
Long run mean moisture	938,129.455	140,436.184	-0.014	-0.006	-0.013
stress periods	(1472332.201)	(227,976.121)	(0.042)	(0.040)	(0.042)

Long run rainfall coefficient of variation	-82,493.989 (119,396.888)	-12,384.202 (19,450.873)	0.003 (0.004)	0.004 (0.003)	0.003 (0.004)
Disease-related PA death of male head/spouse	217,125.422 (1038153.103)	-89,810.195 (143,185.879)	0.037 (0.027)	0.031 (0.039)	0.031 (0.040)
Disease-related PA death of female head/spouse	-817,491.812 (2352263.281)	89,335.413 (325,270.755)	-0.029 (0.0428)	-0.031 (0.034)	-0.024 (0.031)
Disease-related PA death of other male HH member	197,358.347 (517,594.077)	-675.857 (73,002.766)	0.018 (0.016)	0.012 (0.016)	0.014 (0.018)
Disease-related PA death of other female HH member	364,621.056 (624,145.306)	3,659.981 (64,645.884)	0.009 (0.016)	-0.004 (0.018)	-0.006 (0.019)
Landholding size	201,752.439 (321,007.240)	44,313.778 (32,962.718)	-0.006 (0.005)	-0.012* (0.006)	-0.013** (0.006)
Value of farm equipment	2.622 (1.860)	0.313 (0.211)	-0.0000000** (0.0000000)	-0.0000000*** (0.0000000)	-0.0000000*** (0.0000000)
Value of livestock	0.006 (0.147)	0.003 (0.017)	-0.0000000*** (0.0000000)	-0.0000000* (0.0000000)	-0.0000000 (0.0000000)
2004 survey year dummy	-30,328.600 (1722045.092)	57,476.004 (214,848.337)	-0.033 (0.025)	-0.073*** (0.024)	-0.091*** (0.025)
2008 survey year dummy	-678,005.879 (3036440.544)	-135,196.744 (370,389.854)	-0.044 (0.042)	0.030 (0.041)	0.056 (0.041)
Constant	-1.523e+07 (16475558.292)	-1732741.223 (2336125.275)	0.793* (0.444)	1.408*** (0.427)	1.451*** (0.444)
Observations	12,854	12,854	12,854	12,854	12,854
R-squared	0.525	0.521	0.536	0.615	0.608

Note: Robust standard errors in parentheses, clustered by households; *** p<0.01, ** p<0.05, * p<0.10

Table 5. Effects of the Quantity of Maize Sold to the FRA on Household Income and Poverty (Fixed Effects Estimates)

Dependent variable:	(1) **Gross income** (ZMK)	(2) **Per capita income** (ZMK)	(3) **Poverty incidence**	(4) **Poverty gap**	(5) **Poverty severity**
Quantity of maize sold to FRA (kg)	1,774.914***	130.187***	-0.0000179***	-0.0000131***	-0.0000099**
	(455.605)	(47.923)	(0.0000047)	(0.0000045)	(0.0000045)
District maize sales to FRA (kg per agri. HH)	-1,222.155	-231.976*	0.0000441*	0.0000483**	0.0000479*
	(1,133.750)	(140.820)	(0.0000234)	(0.0000241)	(0.0000257)
Control variables	Yes	Yes	Yes	Yes	Yes
Survey year dummies	Yes	Yes	Yes	Yes	Yes
Observations	12,854	12,854	12,854	12,854	12,854
R-squared	0.530	0.522	0.537	0.613	0.604

Note: Robust standard errors in parentheses, clustered by households; *** p<0.01, ** p<0.05, * p<0.10. The control variables included in the regressions are the same as in table 4.

Table 6. Effects of Selling to the FRA on Household Income and Poverty in 2008 (IV with CRE Estimates)

Dependent variable:	(1) **Gross income** (ZMK)	(2) **Per capita income** (ZMK)	(3) **Poverty incidence**	(4) **Poverty gap**	(5) **Poverty severity**
First Stage Regressions (effect of instrument on whether household sold to FRA)					
Distance to nearest FRA depot (km)	-00098***	-00098***	-00098***	-00098***	-00098***
	(0.00017)	(0.00017)	(0.00017)	(0.00017)	(0.00017)
Second Stage Regressions					
Sold to FRA (=1)	19873094.225**	1986109.327**	-0.266	-0.598***	-0.672***
	(9116730.935)	(982,169.505)	(0.194)	(0.211)	(0.223)
District maize sales to FRA (kg per agricultural HH)	-27,767.849	-2,991.768	0.000143	0.000255**	0.000274**
	(18,653.795)	(2,066.023)	(0.000116)	(0.000123)	(0.000131)
Control variables	Yes	Yes	Yes	Yes	Yes
District dummies	Yes	Yes	Yes	Yes	Yes
CRE time averages	Yes	Yes	Yes	Yes	Yes
DWH test	3.679	2.527	0.625	3.424	4.324
P-value	0.055	0.112	0.429	0.064	0.0378
Observations	4,283	4,283	4,283	4,283	4,283

Note: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.10. The control variables included in the regressions include all those highlighted in table 4 as well as agro-ecological region and district dummies. DWH = Durbin-Wu-Hausman.

Table 7. Effects of the Quantity of Maize Sold to the FRA on Household Income and Poverty in 2008 (IV with CRE Estimates)

Dependent variable:	(1) **Gross income** (ZMK)	(2) **Per capita income** (ZMK)	(3) **Poverty incidence**	(4) **Poverty gap**	(5) **Poverty severity**
First Stage Regressions (effect of instrument on quantity of maize sold to FRA)					
Distance to nearest FRA depot (km)	-1.841*** (0.788)	-1.841*** (0.788)	-1.841*** (0.788)	-1.841*** (0.788)	-1.841*** (0.788)
Second Stage Regressions					
Quantity of maize sold to FRA (kg)	10,576.915* (5,784.315)	1,057.095* (608.400)	-0.000142 (0.000109)	-0.000318** (0.000157)	-0.000358** (0.000176)
District maize sales to FRA (kg per agricultural HH)	-28,258.119 (19,374.704)	-3,040.782 (2,134.764)	0.000140 (0.000122)	0.000269* (0.0001545)	0.000290* (0.000172)
Control variables	Yes	Yes	Yes	Yes	Yes
District dummies	Yes	Yes	Yes	Yes	Yes
CRE time averages	Yes	Yes	Yes	Yes	Yes
DWH test	3.605	3.091	1.245	8.173	9.887
P-value	0.058	0.079	0.265	0.004	0.002
Observations	4,283	4,283	4,283	4,283	4,283

Note: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.10. The control variables included in the regressions include all those highlighted in table 4 as well as agro-ecological region and district dummies. DWH = Durbin-Wu-Hausman.

Table 8. Effects of FRA Participation on Different Sources of Income (Fixed Effects Estimates)

Dependent variable:	(1) **Maize income**	(2) **Non-maize crop income**	(3) **Ag wage income**	(4) **Other income**	(5) **Maize income**	(6) **Non-maize crop income**	(7) **Agri. wage income**	(8) **Other income**
Sold to FRA (=1)	2888215.184***	-45,922.673	-19,773.585	1464297.177				
	(377,414.694)	(202,099.767)	(26,565.659)	(952,590.063)				
Quantity of maize sold to FRA (kg)					1,087.970***	158.619	-3.937	532.263**
					(171.348)	(181.123)	(4.033)	(262.910)
District maize sales to FRA (kg/agric. HH)	155.052	-409.252**	51.676	-1,053.933	214.881	-470.086**	50.072	-1,017.021
	(419.482)	(167.019)	(86.224)	(1,029.873)	(361.880)	(186.125)	(86.609)	(1,020.393)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Survey year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	12,854	12,854	12,854	12,854	12,854	12,854	12,854	12,854
R-squared	0.673	0.471	0.562	0.497	0.730	0.477	0.562	0.498

Note: Robust standard errors in parentheses, clustered by households; *** p<0.01, ** p<0.05, * p<0.10. The control variables included in the regressions are the same as in table 4. All values are in ZMK.

Table 9. Effects of FRA Participation on Different Sources of Income in 2008 (IV with CREE)

Dependent variable:	(1) Maize income	(2) Non-maize crop income	(3) Ag wage income	(4) Other income	(5) Maize income	(6) Non-maize crop income	(7) Ag wage income	(8) Other income
	First Stage (effect on whether household sold to FRA)				First Stage (effect on quantity of maize sold to FRA)			
Distance to nearest FRA depot (km)	-00098*** (0.00017)	-00098*** (0.00017)	-00098*** (0.00017)	-00098*** (0.00017)	-1.841*** (0.788)	-1.841*** (0.788)	-1.841*** (0.788)	-1.841*** (0.788)
	Second Stage Regressions							
Sold to FRA (=1)	2159489.496 (1469406.708)	693,333.182 (700,725.792)	-143,960.400 (186,763.215)	17164231.860* (8820744.694)				
Quantity of maize sold to FRA (kg)					1,149.465** (571.765)	369.133 (350.308)	-76.596 (103.836)	9,134.912 (5,777.162)
District maize sales to FRA (kg/agric. HH)	8.349 (818.268)	-566.556 (377.794)	-269.147* (163.206)	-26,940.495 (18,884.666)	-44.979 (667.197)	-583.711 (391.069)	-265.604 (163.824)	-27,363.826 (19,552.744)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CRE time averages	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DWH test	0.169	0.673	0.503	4.001	0.074	0.441	0.538	3.760
P-value	0.681	0.412	0.478	0.046	0.785	0.507	0.463	0.053
Observations	4,283	4,283	4,283	4,283	4,283	4,283	4,283	4,283

Note: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.10. The control variables included in the regressions include all those highlighted in table 4 as well as agro-ecological region and district dummies. All values are in ZMK. DWH = Durbin-Wu-Hausman.

Table 10. Effects of FRA Participation on the Gross Value of Production of Other Crops (Fixed Effects Estimates)

Dependent variable:	(1) Other staples	(2) High value crops	(3) Cash crops	(4) Other staples	(5) High value crops	(6) Cash crops
Sold to FRA (=1)	-108,530.062*	36,259.351	26,523.902			
	(65,672.233)	(38,743.835)	(217,594.853)			
Quantity of maize sold to FRA (kg)				3.880	7.806	138.683
				(18.282)	(7.230)	(187.477)
District maize sales to FRA (kg per agricultural HH)	-325.283***	8.738	99.806	-342.768***	11.481	56.549
	(58.880)	(29.155)	(268.719)	(59.480)	(29.167)	(277.534)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Survey year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	12,854	12,854	12,854	12,854	12,854	12,854
R-squared	0.473	0.551	0.452	0.473	0.551	0.453

Note: Robust standard errors in parentheses, clustered by households; *** p<0.01, ** p<0.05, * p<0.10. The control variables included in the regressions are the same as in table 4. All values are in ZMK.

Table 11. Effects of FRA Participation on the Gross Value of Production of Other Crops in 2008 (IV with CRE Estimates)

Dependent variable:	(1) Other staples	(2) High value crops	(3) Cash crops	(4) Other staples	(5) High value crops	(6) Cash crops
	First Stage (effect on whether household sold to FRA)			**First Stage (effect on quantity of maize sold to FRA)**		
Distance to nearest FRA depot (km)	-00098***	-00098***	-00098***	-1.841***	-1.841***	-1.841***
	(0.00017)	(0.00017)	(0.00017)	(0.788)	(0.788)	(0.788)
	Second Stage Regressions					
Sold to FRA (=1)	-2,742.420	122,449.218	-1325065.732			
	(423,337.414)	(225,553.180)	(923,299.494)			
Quantity of maize sold to FRA (kg)				-1.388	65.209	-705.086
				(225.319)	(123.994)	(613.627)
District maize sales to FRA (kg per agri. HH)	-628.316*	148.616	-563.378	-628.277*	145.580	-530.746
	(321.949)	(131.179)	(386.186)	(325.180)	(135.226)	(467.744)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
District dummies	Yes	Yes	Yes	Yes	Yes	Yes
CRE time averages	Yes	Yes	Yes	Yes	Yes	Yes
DWH test	0.072	0.023	1.832	0.178	0.249	3.460
P-value	0.789	0.879	0.176	0.673	0.618	0.063
Observations	4,283	4,283	4,283	4,283	4,283	4,283

Note: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.10. The control variables included in the regressions include all those highlighted in table 4 as well as agro-ecological region and district dummies. All values are in ZMK. DWH = Durbin-Wu-Hausman.

Table 12. Effects of FRA Participation On Calories Availability (Fixed Effects Estimates)

Dependent variable:	(1) **Calories Availability (per person per day)**	(2) **Calories Availability (per person per day)**
Sold to FRA (=1)	315.915	
	(283.891)	
Quantity of maize sold		0.004
to FRA (kg)		(0.004)
District maize sales to FRA	-1.154***	-1.110***
(kg per agricultural HH)	(0.335)	(0.340)
Control variables	Yes	Yes
Survey year dummies	Yes	Yes
Observations	12,854	12,854
R-squared	0.469	0.469

Note: Robust standard errors in parentheses, clustered by households; *** p<0.01, ** p<0.05, * p<0.10. The control variables included in the regressions are the same as in table 4. All values are in ZMK.

Table 13. Effects of FRA Participation on Calorie Availability In 2008 (IV with CRE Estimates)

	(1)	(2)
Dependent variable:	**Calorie Availability (per person per day)**	**Calorie Availability (per person per day)**
	First Stage Regressions	
Distance to nearest FRA depot (km)	-00098***	-1.841***
	(0.00017)	(0.788)
	Second Stage Regressions	
Sold to FRA (=1)	2,405.906	
	(2,737.828)	
Quantity of maize sold to FRA (kg)		1.281
		(1.552)
District maize sales to FRA (kg per agricultural HH)	-2.196	-2.255
	(1.544)	(1.631)
Control variables	Yes	Yes
District dummies	Yes	Yes
CRE time averages	Yes	Yes
DWH test	0.474	0.760
P-value	0.491	0.383
Observations	4,283	4,283

Note: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.10. The control variables included in the regressions include all those highlighted in table 4 as well as agro-ecological region and district dummies. DWH = Durbin-Wu-Hausman.

APPENDIX

Table A1. First Stage Regression Results for IV/CRE Model (OLS with CRE Estimates)

Dependent variable: Explanatory variables	**(1) Sold to FRA (=1)**	**(2) Quantity of maize sold to FRA (kg)**
Distance to nearest FRA depot (km)	-0.000980***	-1.842**
	(0.000)	(0.788)
District maize sales to FRA (kg per agricultural HH)	0.000072*	0.159
	(0.000)	(0.192)
Number of children under 5	0.000872	4.664
	(0.007)	(47.664)
Number of children aged 5 to 14	0.001069	-13.695
	(0.005)	(28.902)
Number of prime age adults (aged 15 to 59)	0.007827*	-25.540
	(0.004)	(23.742)
Number of adults aged 60 and above	-0.011521	-142.021**
	(0.014)	(55.892)
Education of household head	0.000428	13.591
	(0.003)	(10.689)
Male-headed household (=1)	0.043786**	47.232
	(0.020)	(73.785)
District wage for weeding	-0.001447*	-6.052
	(0.001)	(4.721)
% of households in district earning non-farm income	0.002798	11.993
	(0.003)	(16.673)
% of households in district earning business income	-0.003838**	-15.137***
	(0.002)	(5.871)
% of households in district earning income from other farms	0.009377***	8.297
	(0.003)	(12.696)
District commercial fertilizer price	-0.000569***	-1.277
	(0.000)	(0.936)
Maize producer price, t-1	-0.000811***	-1.914*
	(0.000)	(1.009)
Groundnut producer price, t-1	0.001128**	1.122
	(0.000)	(2.060)
Mixed beans producer price, t-1	-0.000170	-0.649
	(0.000)	(1.157)
Sweet potato producer price, t-1	-0.003283***	-6.043**
	(0.001)	(2.385)
Growing season rainfall	0.000040	-0.382
	(0.000)	(0.990)
Growing season rainfall, t-1	-0.000348	-2.173**
	(0.000)	(1.106)
Growing season rainfall, t-2	0.000024	0.902
	(0.000)	(1.151)
Growing season rainfall, t-3	-0.000394	-4.824***
	(0.000)	(1.574)
Long run mean growing season rainfall	0.002620	13.181

	(0.002)	(11.025)
Long run mean moisture stress periods	0.018801	381.475
	(0.094)	(429.918)
Long run rainfall coefficient of variation	0.027295*	134.096**
	(0.015)	(63.647)
Disease-related PA death of male head/spouse	-0.046690	-195.286
	(0.065)	(574.149)
Disease-related PA death of female head/spouse	-0.003402	112.341
	(0.068)	(283.051)
Disease-related PA death of other male HH member	0.051230*	186.762
	(0.030)	(125.324)
Disease-related PA death of other female HH member	-0.013554	-123.598
	(0.028)	(102.001)
Landholding size	0.013453***	201.249**
	(0.005)	(79.149)
Value of farm equipment	0.000000*	0.000
	(0.000)	(0.000)
Value of livestock	0.000000	0.000***
	(0.000)	(0.000)
Km from the SEA to the nearest district town	0.000798***	1.993
	(0.000)	(1.214)
Km from the SEA to the nearest main road	0.000136	-1.847
	(0.000)	(1.475)
Km from the SEA to the nearest feeder road	-0.004095***	-11.342
	(0.002)	(7.134)
Number of moisture stress periods	0.014490	110.608*
	(0.016)	(64.953)
Constant	-0.666979	-3,014.097
	(0.758)	(3,032.649)
Agro-ecological region dummies	Yes	Yes
District dummies	Yes	Yes
CRE time averages	Yes	Yes
Observations	4,283	4,283
R-squared	0.168	0.233
p-value for excluded instrument	0.000	0.020
F-statistic for excluded instrument	34.82	5.46

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.10.

Table A2. Effects of FRA Participation on Log Income (Fixed Effects Estimates)

	(1)	(2)	(3)	(4)
Dependent variable:	**Ln(gross income)**	**Ln(per capita income)**	**Ln(gross income)**	**Ln(per capita income)**
Sold to FRA (=1)	0.541557***	0.530572***		
	(0.062531)	(0.065687)		
Quantity of maize sold			0.000051***	0.000049***
to FRA (kg)			(0.000015)	(0.000015)
District maize sales to FRA	-0.000227**	-0.000235**	-0.000163*	-0.000172*
(kg per agricultural HH)	(0.000089)	(0.000093)	(0.000089)	(0.000093)
Control variables	Yes	Yes	Yes	Yes
Survey year dummies	Yes	Yes	Yes	Yes
Observations	12,813	12,813	12,813	12,813
R-squared	0.659	0.612	0.656	0.609

Note: Robust standard errors in parentheses, clustered by households; *** p<0.01, ** p<0.05, * p<0.10. The control variables included in the regressions are the same as in table 4.

Table A3. Effects of FRA Participation on Log Income in 2008 (IV with CRE Estimates)

	(1)	(2)	(3)	(4)
Dependent variable:	**Ln(gross income)**	**Ln(per capita income)**	**Ln(gross income)**	**Ln(per capita income)**
Sold to FRA (=1)	2.446***	2.306***		
	(0.809)	(0.809)		
Quantity of maize			0.001**	0.001**
sold to FRA (kg)			(0.001)	(0.001)
District maize sales to	0.001	0.001	0.001	0.002
FRA (kg per agri. HH)	(0.001)	(0.001)	(0.002)	(0.002)
Control variables	Yes	Yes	Yes	Yes
District dummies	Yes	Yes	Yes	Yes
CRE time averages	Yes	Yes	Yes	Yes
Observations	4,274	4,274	4,274	4,274

Notes: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.10. The control variables included in the regressions are the same as in table 4.