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Do crop purchase programs improve smallholder welfare? The case of Zambia's Food Reserve Agency

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Abstract

Government and parastatal crop purchase programs have regained popularity in sub-Saharan Africa, with many citing improving smallholder farmers' welfare as a key goal. Yet there is limited empirical evidence on the topic. This paper analyzes the effects of the Zambian Food Reserve Agency's (FRA's) maize purchase activities on smallholder welfare. The FRA buys maize at a pan-territorial price that often exceeds market prices in surplus production areas. Using two household panel survey datasets spanning 15 years and exploiting variation in the scale of FRA activities over time, we employ fixed effects and control function approaches to estimate the effects of a smallholder household's maize sales to the FRA on its welfare, as well as the effects of more intense FRA maize purchase activity in a given district on the welfare of smallholder households in the district. Results suggest positive direct welfare effects on the minority of smallholders that sell to the FRA. We also find that, in the early years of the program, more intense FRA maize purchase activity in a district was associated with reductions in smallholder welfare, particularly among maize autarkic and net buying households. In later years, we find no evidence of such negative effects and some evidence of positive district-level effects on maize net buyers.

KEYWORDS

crop marketing boards, income, maize, poverty, smallholder farmers, strategic grain reserves

JEL CLASSIFICATION

I3, Q1, Q13, Q18, O2, O1

1 | INTRODUCTION

Historically, while agricultural policies and crop marketing institutions in developed countries tended to subsidize farmers at the expense of urban consumers, such policies and institutions in developing countries often taxed farmers to the benefit of urban consumers and industries (Barrett & Mutambatsere, 2005; Kolavalli & Vigneri, 2018; Tadei, 2018). Following the push for government exit from private markets that accompanied structural adjustment programs (SAPs) in the 1980s and 1990s, numerous governments or parastatal crop marketing boards throughout the developing world were dismantled or had their activities markedly scaled back (Jayne & Jones, 1998; Kherallah, Delgado, Gabre-Madhin, Minot, & Johnson, 2002; Lefèvre & Tharakan, 2018). However, since the mid-2000s, there has been a resurgent interest in the potential for crop marketing boards to address key challenges of smallholder access to output markets and price stability for producers and consumers (Abbink, Jayne, & Moller, 2011; Deuss, 2015; Galtier et al., 2018; Musselli, 2017; Sitko, Chamberlin, Cunguara, Muyanga, & Mangisoni, 2017). Though sometimes restricted to the management of strategic

reserves or insurance against extraordinary price fluctuations, grain marketing boards (GMBs) have again become commonplace in sub-Saharan Africa (SSA) (Chapoto & Jayne, 2009; Jayne, Myers, & Nyoro, 2008; Jayne et al., 2010; Mason & Myers, 2013; Mason, Jayne, & Myers, 2015; Musselli, 2017; Noma, 2018; Pierre, Pauw, & Magrini, 2018; Rashid, Alemu, & Dorosh, 2019; Rashid, Dorosh, & Alemu, 2018; Zhou & Baylis, 2019). Yet there is limited empirical evidence on how the activities of these GMBs affect smallholder farmers' welfare. To date, most empirical studies (including those cited above) have focused on the effects of the programs on price levels, price volatility, and crop production patterns.

This paper adds to the thin evidence base on the welfare effects of the recent wave of GMBs in SSA by empirically estimating the effects of the maize purchase activities of the Zambian Food Reserve Agency (FRA) on the economic well-being of smallholder farm households.[1] The FRA, a parastatal GMB/strategic food reserve, was established by the Food Reserve Act of 1995. The FRA seeks to ensure national food security and incomes and to stabilize crop prices by maintaining a national strategic food reserve (FRA, 2011, 2018). The FRA is one of Zambia's two major agricultural sector poverty reduction programs geared toward smallholder farmers.[2] FRA's crop marketing activities have focused on maize, and in many years since the mid-2000s, the Agency was the country's dominant buyer of smallholder farmers' maize (Figure 1). It purchases maize from farmers at its depots throughout rural Zambia at a pan-territorial price that often (but not always) exceeds the maize prices offered by private buyers in major maize-producing areas.[3] The FRA then stores the maize, exports it, or sells it on the domestic market at potentially below-market prices, mainly to select large-scale millers in major urban centers to be ground into maize meal for nshima, the main staple food in the country (Chapoto & Jayne, 2009; Mason & Myers, 2013; Mason et al., 2015). Previous studies suggest that little if any of these savings are passed on to consumers (Kuteya, Chisanga, & Sitko, 2014).

Although selling to the FRA at above-market prices has the potential to raise farmer incomes, FRA activities may also have unintended, negative effects on smallholders, particularly those that do not sell to the FRA. For example, the FRA's pricing and buying/selling activities are often implemented in an ad hoc and unpredictable manner. In particular, the timing of the FRA's announcement of its pan-territorial maize purchase price and the start and end dates of its maize purchase activities vary considerably from year to year, and the target purchase quantities it announces rarely align with the quantities it ultimately purchases.[4] 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 (Chapoto & Jayne, 2011). Furthermore, FRA's maize purchase 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 maize prices to the potential benefit of maize net sellers but to the detriment of rural maize net buyers and urban consumers (Mason & Myers, 2013; Singh, Squire, & Strauss, 1986).[5,6] 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 into maize meal at hammer mills, which is typically a more affordable option than buying maize meal produced in large-scale commercial mills (Mason & Jayne, 2009). In addition, analysis by Mason and Myers (2013) suggests that FRA activities stabilized maize prices between 1996 and 2008; however, as the authors argue (but do not empirically test), this price stabilization is likely to have mainly benefited large-scale farmers as opposed to consumers or smallholder farmers.[7]

This paper contributes to the literature in four ways. First, it adds to the thin empirical evidence base on the welfare

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

[2] The second poverty reduction program is the Farmer Input Support Program (FISP), a targeted agricultural input subsidy program.

[3] Two recent exceptions are the 2016/2017 and 2018/2019 marketing years when the FRA price was below prevailing market prices in much of the country. See Figure S1 in Supporting Information in the online appendix for the FRA's pan-territorial maize purchase price in each maize marketing year (May through April) from 1996/1997 to date. In the marketing years covered in the household panel survey data used in this study, the FRA price was consistently higher than non-FRA maize producer prices in most of the country. For example, the FRA price exceeded the median district non-FRA maize producer price in 59 of 70 rural districts in 2003/2004, 61 of 70 rural districts in 2007/2008, 71 of 74 rural districts in 2011/2012, and 72 of 74 rural districts in 2014/2015. The total number of districts varies because the Zambian government subdivided some districts to create new districts.

[4] See Supporting Information in the online appendix for additional information on how the FRA determines its annual demand, when it announces its pan-territorial price and purchase target, and related details.

[5] This is a key insight from agricultural household models, which acknowledge the dual role of agricultural households as both producers and consumers of agricultural staples such as maize (Singh, Squire, & Strauss, 1986). The other two studies cited make this point for Zambia but do not empirically estimate the welfare effects.

[6] Note that only a minority of Zambian smallholder households are maize net sellers (see Table 1). For example, during the 2007/2008 maize marketing year, approximately 51% were maize net buyers, 22% neither bought nor sold maize (i.e., were maize autarkic), and 27% were maize net sellers. During the 2011/12 marketing year, 27% were net buyers, 30% were autarkic, and 43% were net sellers; and during the 2014/2015 marketing year, 39% were net buyers, 25% were autarkic, and 36% were net sellers. The vast majority of households that sell maize to the FRA are maize net sellers (Table 1).

[7] Relatedly, evidence from rural Ethiopia suggests that stabilizing food prices disproportionately benefits higher-income households and may actually be detrimental for poor rural households (Bellemare, Barrett, & Just, 2013).

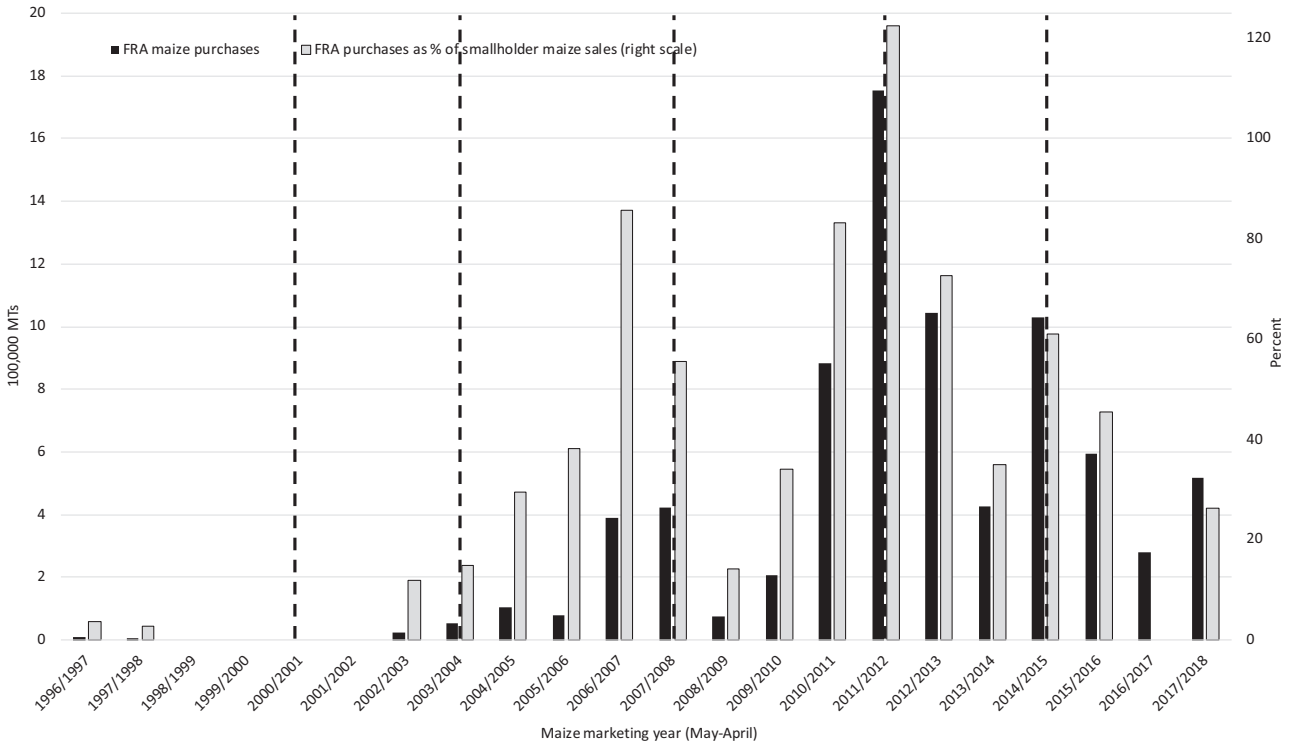

FIGURE 1 FRA maize purchases by maize marketing year, 1996/1997–2017/2018

Notes: The vertical dotted lines correspond to the maize marketing years captured in our data: 2000/2001, 2003/2004, and 2007/2008 in the CSO/MACO/FSRP Supplemental Survey data, and 2011/2012 and 2014/2015 in the CSO/MAL/IAPRI Rural Agricultural Livelihoods Survey data. FRA purchases as percentage of smallholder maize sales = (total FRA purchases/total estimated smallholder sales) × 100; this value exceeds 100% in 2011/2012 because the Agency also buys some maize from large-scale farmers and traders. Data on smallholder maize sales for 2016/2017 not available.

Source: Food Reserve Agency and Zambia Ministry of Agriculture.

TABLE 1 Smallholder households' maize market position and percentage selling to the FRA

		Maize market position category			
Survey and marketing year	**Description**	**Net seller**	**Autarkic**	**Net buyer**	**All HHs**
SS—2000/2001[a]	% of all HHs	25.7	37.9	36.3	100
SS—2003/2004	% of all HHs	24.3	37.8	37.9	100
	% of all HHs selling to FRA	92.5	0	7.5	100
	% of HHs in category selling to FRA	2.9	0	0.2	0.8
SS—2007/2008	% of all HHs	27.3	22.2	50.5	100
	% of all HHs selling to FRA	98.0	0	2.0	100
	% of HHs in category selling to FRA	34.9	0	0.4	9.7
RALS—2011/2012	% of all HHs	43.3	29.5	27.2	100
	% of all HHs selling to FRA	99.6	0	0.4	100
	% of HHs in category selling to FRA	64.2	0	0.4	27.9
RALS—2014/2015	% of all HHs	35.8	25.2	39.1	100
	% of all HHs selling to FRA	83.2	0	16.8	100
	% of HHs in category selling to FRA	50.4	0	9.3	21.7

[a]There are no rows related to the FRA for SS—2000/2001 because the FRA bought no maize that year.

Sources: Authors' calculations using the SS and RALS analytical samples. See the Data section for details.

effects of post-SAP GMB activities on African smallholders. Most studies on post-SAP government agricultural sector programs have focused on input subsidies (see Jayne, Mason, Burke, and Ariga (2018) and Holden (2019) for reviews). And although several published studies have considered the effects of post-SAP GMB activities on maize market prices (Jayne et al., 2008; Mason & Myers, 2013; Pierre et al., 2018) or smallholder crop production patterns (Mason et al., 2015), to the best of our knowledge, no previous peer-reviewed study has empirically estimated the welfare effects on smallholder farmers of a post-SAP GMB crop purchase program that buys mainly from these farmers.[8]

Second, this paper is the first to econometrically estimate the welfare effects of the FRA's maize purchase program. Though previous studies have discussed the likely welfare effects of the program (e.g., Kuteya et al., 2014; Mason & Myers, 2013; Mason et al., 2015), none have explicitly estimated these effects. And while we focus on the FRA here, insights from this paper are relevant for other countries that currently have a GMB similar to the FRA or are considering establishing one.

Third, we estimate both the direct effects of a smallholder household's maize sales to the FRA on its welfare, as well as the effects of more intense FRA maize purchase activity in a given area on the welfare of smallholder households in that area. Only a minority of smallholders sell maize to the FRA (e.g., 10% of all smallholders in 2007/2008, 28% in 2011/2012, and 22% in 2014/2015), and these tend to be wealthier households with more land (Table 2; see also Mason et al., 2015). Although such farmers may earn higher incomes from these sales due to the above-market prices typically offered by the Agency, given the already elevated wealth status of many of these farmers, this may have little or no impact on rural poverty rates; indeed, these rates have remained high (77–83%) since the FRA was established (Mason et al., 2015; CSO, various years). Moreover, given the discussion above about potential unintended consequences of the FRA's maize purchase activities (e.g., siphoning maize out of rural areas and distorting maize markets and trader activity), it is an empirical question whether more intense FRA purchase activity in a given area on average positively or negatively affects smallholder welfare—particularly that of households that are not maize net sellers. This paper therefore adds to a growing literature on the potential unintended consequences of otherwise well-intended poverty alleviation programs in developing countries.

Fourth, we analyze data from two nationally representative panel surveys of smallholder farm households: the Zambia Supplemental Survey (SS) and the Rural Agricultural Livelihoods Survey (RALS). These datasets, which are described in detail in the next section, are comparable in many ways but cover different periods in the FRA's evolution: the SS covers years before and during the scale-up of the FRA's maize purchase activities, and the RALS covers years at the peak of these activities (see Figure 1). Analyzing both datasets enables us to explore if and how the welfare effects of these activities have changed over time.

The paper proceeds as follows. In the next section, we describe the data used in the analysis. We then present the empirical strategy, results, and conclusions.

2 | DATA

The data used in this study are drawn mainly from the Zambia SS and RALS. The SS is a three-wave household panel survey that was 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. It covers the 1999/2000, 2002/2003, and 2006/2007 agricultural years (October–September) and the subsequent maize marketing years (May–April of 2000/2001, 2003/2004, and 2007/2008). The RALS is a two-wave household panel survey that was implemented in mid-2012 and 2015 by the same set of partners (although MACO was renamed the Ministry of Agriculture and Livestock [MAL] during the RALS years and FSRP became the Indaba Agricultural Policy Research Institute [IAPRI]). The RALS covers the 2010/2011 and 2013/2014 agricultural years and the corresponding maize marketing years (2011/2012 and 2014/2015).

The SS and RALS focus on the same population (smallholder farm households throughout Zambia) and cover the same provinces and districts but a new random sample from this population was drawn for the RALS.[9] The questions asked on the SS and RALS are also largely similar to the 2008 wave of the SS served as the basis for the RALS 2012 survey instrument. The SS and RALS both capture detailed information on household demographics, crop and livestock production and sales, income from all on- and off-farm sources, and

[8] Mghenyi, Myers, and Jayne (2011) estimate the welfare effects of a 25% maize price increase in Kenya in 2004 on rural incomes and poverty. This maize price increase is similar (though larger) in magnitude to that induced by the maize marketing activities of Kenyan National Cereals and Produce Board (NCPB), a maize marketing board, from 1995 to 2004 (Jayne, Myers, & Nyoro, 2008) but Mghenyi et al. do not estimate the welfare effects of NCPB's maize marketing activities per se. Moreover, the NCPB's approach is fundamentally different from the FRA's in that the NCPB buys very little maize from smallholders; instead, it buys almost all of its maize from large-scale commercial farmers and assembly traders. In contrast, the FRA buys predominately from smallholders (Mason & Myers, 2013).

[9] For more information on the SS data and sampling design, see Megill (2005) and Mason, Jayne, and Myers (2015); for similar information on the RALS, see IAPRI (2012).

TABLE 2 Smallholder maize sales to the FRA by landholding size category, 2007/08, 2011/12, and 2014/15 maize marketing years

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	
Panel A: 2007/2008 marketing year					
0–0.99 ha	30.3	2.2	12	529	1.3
1–1.99 ha	34.9	7.6	79	1,040	10.2
2–4.99 ha	28.3	16.1	340	2,109	35.8
5+ ha	6.6	28.4	2,161	7,608	52.7
All HHs	100	9.7	269	2,764	100
Panel B: 2011/2012 marketing year					
0–0.99 ha	29.4	10.6	98	920	3.6
1–1.99 ha	31.6	24.8	334	1,346	13.3
2–4.99 ha	31.9	40.0	989	2,473	39.9
5+ ha	7.1	58.7	4,785	8,156	43.1
All HHs	100	27.9	791	2,835	100
Panel C: 2014/2015 marketing year					
0–0.99 ha	21.3	6.9	56	820	1.7
1–1.99 ha	29.1	16.5	237	1,434	9.5
2–4.99 ha	37.5	28.1	761	2,713	39.5
5+ ha	12.1	40.4	2,940	7,276	49.3
All HHs	100	21.7	723	3,334	100

Sources:Authors' calculations using the 2008 SS and the 2012 and 2015 RALS analytical samples. See the Data section for details.

other socio-economic factors. Some information on food purchases is also captured: maize and other staple foods in the SS but only maize in both waves of the RALS. One other difference between the surveys is that the RALS includes several questions on a household's distance from key locations and services (including the nearest FRA depot), whereas these questions were not included in the SS. (We discuss this issue in further detail in the Empirical Strategy section.)

In terms of sample sizes and attrition, 6,922 households were interviewed in the first wave of the SS. Of these, 5,358 (77%) were reinterviewed in the second wave; and of those, 4,286 (80%) were reinterviewed in the third wave. For the RALS, 8,839 households were interviewed in the first wave, and 7,254 (82%) were reinterviewed in the second wave. The balanced panel of SS data used in this paper consists of 4,282 households (yearly) and 12,846 observations total; for the RALS, the balanced panel used for analysis consists of 7,237 households (yearly) and 14,474 observations total.[10]

Given attrition between survey waves, there is the potential for attrition bias, so we test for it using the approach recommended by Wooldridge (2010). We fail to reject at the 10% level the null hypothesis of no attrition bias for all dependent variables for the SS data and for seven of the eight dependent variables for the RALS data. The test results therefore suggest that attrition bias is a not a major concern in this paper. See Supporting Information in the online appendix for a description of the test, the test results, and additional discussion.

We supplement the SS and RALS data with: (a) information from FRA administrative records on its total district-level maize purchases from all sellers (smallholders, larger-scale farmers, and traders) by marketing year;[11] (b) geo-referenced rainfall data from the Tropical Applications of Meteorology using SATellite data (TAMSAT) (Grimes, Pardo-Igúzquiza, & Bonifacio, 1999; Maidment et al., 2014; Milford & Dugdale, 1990; Tarnavsky et al., 2014); and (c) data from the Zambia Crop Forecast Surveys (CFSs) for the 2002/2003, 2006/2007, 2010/2011, and 2013/2014 agricultural years on the total maize area planted and quantity of maize expected to be harvested by all farmers (smallholder and larger scale) by district.[12] We discuss how these data are utilized in the next section. For (a), the district level is the lowest level of aggregation at which FRA makes these data available and

[10] The analytical sample is slightly less than the full balanced panel in both the SS and RALS cases due to missing data or extreme values for a small number of households.

[11] Although official FRA regulations require that sellers to the FRA be smallholder farmers, large-scale farmers and traders also sell to the FRA.

[12] The CFSs are conducted annually by CSO and the Ministry of Agriculture. The data are collected in late March and early April when maize has reached physiological maturity but has not yet been harvested. Thus, the area planted data reflect actual area planted but the maize production data are farmers' estimates of how much they are likely to harvest.

these totals include maize purchased by the FRA at all of its depots (main and satellite) in a given district.

3 | EMPIRICAL STRATEGY

From an impact evaluation standpoint, the SS data are particularly well suited to study the effects of FRA's maize purchase activities on smallholders. The first wave of the SS covers a marketing year (2000/2001) in which the FRA did not purchase maize domestically due to limited funding, nor had it done so in the two previous years (Figure 1). The first wave of the SS also occurred before 2002/2003 when the FRA began buying maize directly from smallholders. (Its previous purchases, which occurred in 1996/1997 and 1997/1998, were made through private traders.) As of the 2003/2004 marketing year, captured in the second wave of the SS, the FRA was buying directly from smallholders but its total maize purchases were less than 55,000 metric tons (MT) procured from only 36 of 72 districts in the country. However, in the 2007/2008 marketing year, which is covered by the third wave of the SS, the FRA had expanded its purchases to 58 of 72 districts and bought nearly 400,000 MT of maize (Figures 1 and 2). Changes in the geographic coverage and scale of the FRA's purchase activities over the SS waves create a natural experiment that we leverage to identify the effects of its maize purchase activities on smallholder welfare. The RALS data provide another opportunity to estimate the effects of the FRA's maize purchase activities on smallholder welfare but covers later years (the 2011/2012 and 2014/2015 marketing years) after the FRA was already a well-established player in Zambian maize markets. We thus view the SS results as the main estimates for how introducing a maize purchase program like the FRA's affects smallholder welfare, and the RALS results as reflecting the program's impacts after maize markets have adjusted to the FRA's perennial involvement.

To estimate the effects of a smallholder household's maize sales to the FRA (FRA_HH_{idt}) and the effects of the intensity of FRA maize purchase activity in a given district (FRA_INT_{dt}) on smallholder welfare, our starting point is the following unobserved effects panel data model:

$$y_{idt} = \beta_1 FRA\_HH_{idt} + \beta_2 FRA\_INT_{dt} + \boldsymbol{x}_{idt}\boldsymbol{\rho} + c_i + \mu_t + \varepsilon_{idt} \quad (1)$$

where i, d, and t index the household, district, and year, respectively. y_{idt} is household income or other measures of welfare; $\boldsymbol{x}_{idt}$ is a vector of other covariates that may affect household welfare; c_i is time-invariant unobserved household-specific heterogeneity that could be correlated with the observed covariates; μ_t are year fixed effects (which we control for by including year dummies in all models); ε_{idt} is the idiosyncratic error term; and β_1, β_2, and $\boldsymbol{\rho}$ are parameters to be estimated. In the rest of this section, we describe the explanatory and dependent variables in more detail and then describe our identification strategy. Equation (1) is estimated separately with the SS and then RALS datasets.

We use two different measures of FRA_HH_{idt} (in separate model specifications): (a) a binary variable that equals one if household i sold any maize to the FRA in year t, and zero otherwise; and (b) the quantity (in kg) of maize sold by the household to the FRA. We do this because the quantity of maize sold to the FRA among selling households varies considerably.

Our main measure of FRA_INT_{dt} is the total quantity of maize purchased by the FRA (from all seller types) in district d in year t divided by the total maize area planted in that district and year.[13] Larger values of this measure reflect more intense FRA maize purchase activity in the district. As a robustness check, we use an alternative measure of FRA_INT_{dt} where we divide total FRA purchases by total expected maize production (MT to be harvested) in the district and scale the result by 100. This alternative measure thus represents the percentage of expected maize production in a given district that is purchased by the FRA. While this alternative is perhaps more intuitive as a measure of the intensity of FRA maize purchase activity in a given district, we focus mainly on the first measure due to concerns about measurement error in the expected maize production data.

β_1 is the average effect of a household's direct participation in FRA's maize purchase program. While we expect β_1 to be positive/welfare improving since selling to the FRA at above-market prices has the potential to raise farmer incomes, holding other factors constant, the welfare effect may not be statistically different from zero given that many households that sell to the FRA are already better off (e.g., see Table 2). Concerning the sign and significance of β_2 and recalling the discussion of potential unintended consequences in the Introduction, it is not clear a priori whether an increase in the intensity of FRA maize purchase activity in a district will have a positive, negative, or no statistically significant effect on the welfare of smallholder farmers in that district; it is an empirical question. The welfare effects of the FRA may also differ by the maize market position (MMP) (net buyer, net seller, or autarkic) of a given household, and so we estimate pooled models and models that disaggregate households by their MMP. It is important to note that while our approach provides econometric estimates of the effects of greater intensity of FRA maize activity in a given district on smallholder welfare in that

[13] As noted in the Data section, the district is the most disaggregated level at which FRA administrative data on its total maize purchases are available. District towns are often important economic hubs and the economic activity in a given district is often organized around these towns. Although districts are administrative units, it is fairly common to analyze economic activity of such units—for example, as one would analyze state- or county-level activity in the United States.

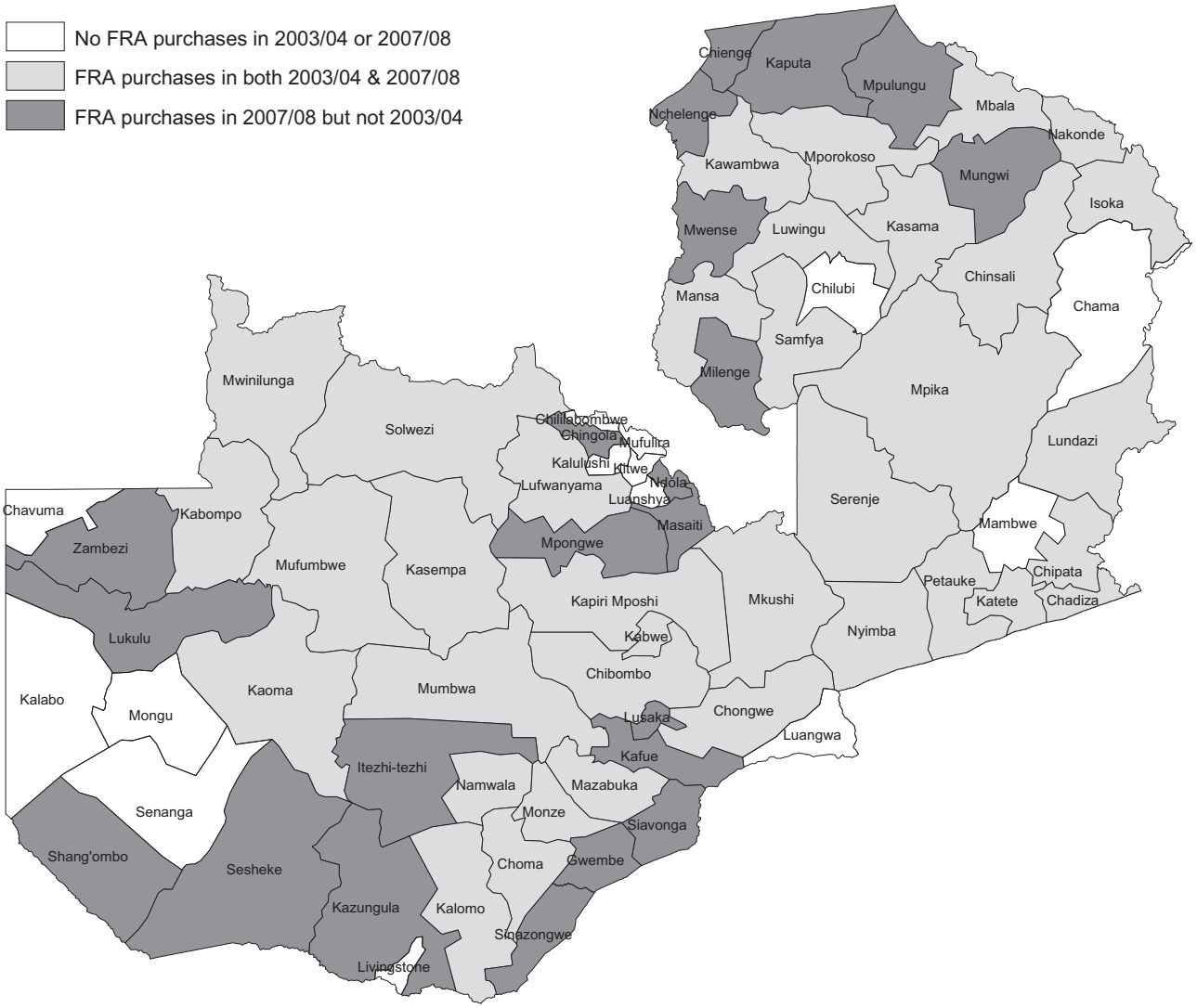

FIGURE 2 Districts where the FRA purchased maize, 2003/2004 and 2007/2008

Note: By the time of the RALS marketing years, the FRA had purchased maize in all districts depicted above in at least 1 year except for Chilubi, Livingstone, Luangwa, and Kalabo.

Source: Food Reserve Agency.

district, a multi-market or computable general equilibrium modeling approach would be required to fully account for the general equilibrium effects of the FRA's maize marketing activities.

The control variables included in $\boldsymbol{x}_{idt}$ are informed by a non-separable agricultural household model (AHM, see, for example, Sadoulet & de Janvry, 1995; Singh et al., 1986; and Bardhan & Udry, 1999). Per Otsuka, Cordova, and David (1992), in a non-separable AHM, income can be modeled as a function of input prices, household land and labor availability, and other exogenous factors and household characteristics affecting the household's production environment and consumption preferences. $\boldsymbol{x}_{idt}$ therefore includes an agricultural wage rate and the commercial fertilizer price in the household's area; the household's landholding size and number of household members in various age groups; the gender, age, and education of the household head; the household's ownership of non-land farm assets; current, recent, and long-run rainfall conditions in the household's area; proxies for off-farm income-generating opportunities in the household's district; and recent household-level shocks (deaths in the household). We also control for the potentially confounding effects of Zambia's input subsidy program (FISP) on household welfare by including a dummy variable that equals one if the household received subsidized fertilizer through FISP, and zero otherwise. See Table S1 in Supporting Information in the online appendix for the complete detailed list of control variables and associated summary statistics.

TABLE 3 Summary statistics for key variables

	SS			RALS		
	Mean	**Median**	**SD**	**Mean**	**Median**	**SD**
Outcome variables						
Gross total income (ZMW)	11,988	4,837	44,235	21,092	9,342	62,276
Gross per capita income (ZMW)	1,908	857	5,601	3,649	1,733	11,929
Household is poor (= 1)	0.856	1	0.351	0.699	1	0.459
Poverty gap	0.594	0.710	0.329	0.398	0.413	0.337
Poverty severity	0.461	0.504	0.322	0.272	0.171	0.289
Maize income (ZMW)	2,830	1,037	8,231	3,520	1,472	8,805
Non-maize crop income (ZMW)	1,910	865	4,026	3,499	1,640	5,420
Other income (ZMW)	7,248	1,063	41,911	14,073	3,049	60,062
Calories available/AE/day	3,404	2,376	4,325	–	–	–
Main explanatory variables						
HH sold maize to FRA (= 1)	0.035	0	0.184	0.248	0	0.432
HH maize sales to FRA (kg), including zeroes	95	0	1,061	757	0	2,812
HH maize sales to FRA (kg), excluding zeroes	2,731	1,250	5,003	3,053	1,500	4,989
[a]District-level FRA maize purchases (MT/ha of maize), incl. zeroes	0.195	0.049	0.300	1.151	0.999	1.341
District-level FRA maize purchases (MT/ha of maize), excl. zeroes	0.367	0.307	0.326	1.192	1.017	1.347
[b]District-level FRA maize purchases (% of expected maize production), incl. zeroes	13.7	2.1	21.1	47.0	42.6	49.9
District-level FRA maize purchases (% of expected maize production), excl. zeroes	25.9	19.2	22.9	48.7	43.7	49.9

Notes: Zambian Kwacha (ZMW) values are in real 2017 terms. 2017 exchange rate: 9.5 ZMW/US$. N = 12,846 for SS; N = 14,474 for RALS. [a]Main ([b]alternative) measure of district-level intensity of FRA maize purchase activity.

We consider several household-level welfare indicators as outcome variables (y_{idt}): (a) real gross household income; (b) real gross household income per capita, (c) a dummy variable equal to one if household income is below the US$1.90 international poverty line and zero otherwise; (d) the household's poverty gap (equal to zero if the household is non-poor and equal to the proportional difference between household per capita income and the US$1.90 poverty line otherwise); and (e) the household's poverty severity (the square of its poverty gap) (Foster, Greer, & Thorbecke, 1984). We also decompose gross household income into three mutually exclusive and exhaustive components: gross maize income, gross income from the production of crops other than maize ("non-maize crop income"), and gross income from activities other than crop production ("other non-crop income").[14] One additional welfare indicator analyzed for the SS data is household calorie availability per adult equivalent (AE) per day. Calorie availability is estimated as the calories from own crop production that is retained (not sold) plus calories from purchased staple foods (the SS did not capture purchases of non-staples) and calories from retained own production of milk and eggs. (See Wineman (2013) for details). We do not analyze calorie availability in the RALS data because the only food purchases captured in the RALS panel are maize purchases. Additional details on these welfare indicators are given in Supporting Information in the online appendix. Table 3 presents summary statistics for these variables as well as FRA_HH_{idt} and FRA_INT_{dt}.

The main challenge in obtaining unbiased and consistent estimates of the parameters in Equation (1) is the potential endogeneity of household maize sales to the FRA (FRA_HH_{idt}) to household welfare. We use a number of strategies to deal with this issue. First, we control for a rich set of observed covariates ($\boldsymbol{x}_{idt}$, described above), effectively taking them out of the error term to reduce the likelihood of omitted variables bias. Previous work on the main factors affecting a household's probability of selling to the FRA points to landholding size (which affects, inter alia, how much land a household allocates to maize vs. other crops) and other factors affecting a household's ability to generate a marketable surplus of maize as the main drivers (Mason et al., 2015). Landholding size, farm equipment, and household size are explicitly controlled for in our regressions, as are agro-climatic factors and input prices that are likely to affect input use decisions and production/marketable surplus outcomes.

[14] It is important to note that crop income in the SS and RALS data is based on crops produced during the agricultural year covered in a given survey wave (e.g., October 1999–September 2000 for the first wave of the SS), harvested, and then potentially sold during the corresponding marketing year (e.g., May 2000–April 2001 for the first wave of the SS)). The reference period in the SS and RALS data for income from activities other than crop production, which compose "other non-crop income" (e.g., income from livestock production and off-farm activities) is the marketing year covered in a given survey (e.g., May 2000–April 2001 for the first wave of the SS).

A household's distances from the nearest marketplace and town (which could affect the number of other buyers it can sell to, inter alia) are implicitly controlled for through our use of the fixed effects (FE) estimator (discussed below) under the assumption that the distances do not vary substantially across survey waves.[15] Another factor that could affect a household's decision to sell to the FRA is how liquidity constrained it is. While private buyers pay cash on the spot, farmers often have to wait months to be paid for maize sold to the FRA. Household liquidity is positively correlated with wealth, and our controls for the household's non-land farm assets serve as proxies for the household's liquidity status. We also include interactions of province and year dummies in all regressions to control for time-varying provincial-level effects. Because it is at the district level, FRA_INT_{dt} is arguably exogenous to the individual smallholder household.[16]

The second element of our identification strategy is our use of the FE estimator. This leverages the household panel nature of the SS and RALS data and controls for time-invariant unobserved household-level factors (c_i) that may be correlated with FRA_HH_{idt} and household welfare and that if left uncontrolled, would cause FRA_HH_{idt} to be endogenous to household welfare.[17]

The remaining potential source of omitted variables bias is correlation between FRA_HH_{idt} and time-varying unobservables that affect household welfare (ε_{idt}). To test and correct for this potential source of endogeneity, we employ the control function (CF) approach (see, e.g., Wooldridge (2010), Wooldridge (2015), and the references therein). In the context of this study, we implement the CF approach by estimating a first stage correlated random effects (CRE) probit (tobit) model in which the dependent variable is the binary variable for whether the household sold maize to the FRA (continuous variable for the kg of maize sold by the household to the FRA) and the explanatory variables are the control variables from Equation (1) ($\boldsymbol{x}_{idt}$), their household-level time averages (for the CRE approach), and an instrumental variable (IV).[18] We use the CRE approach in the first stage in order to control for time-invariant unobserved heterogeneity in a way that is compatible with nonlinear-in-parameters models such as probit and tobit; an FE approach in these models is known to lead to inconsistent parameter estimates.[19] The generalized residuals (GR) from the first stage regression are then used as an additional covariate in a second stage FE regression similar to Equation (1); standard errors are bootstrapped to account for the GRs being generated regressors. Conditional on the validity of the IV, inclusion of the GR corrects for the endogeneity of FRA_HH_{idt} if it is indeed endogenous. Moreover, a t-test of the statistical significance of the GR tests the null (alternative) hypothesis that FRA_HH_{idt} is exogenous (endogenous) to household welfare after controlling for the observed covariates and household FE.

To have a valid IV, we need the IV to be strongly correlated with FRA_HH_{idt} but uncorrelated with ε_{idt}. The IV used here is the distance (in km) from a household's homestead to the nearest FRA depot. (See Table S1 in Supporting Information in the online appendix for summary statistics.) We only employ the CF approach in the RALS analysis because this variable was only collected in the last wave of the SS, and so CF first and second regressions with the SS data would be cross-sectional and would not leverage the panel nature of the SS data.[20] The argument for this IV is as follows. A household's distance from the nearest FRA depot is likely to be an important (highly statistically significant) determinant of its maize sales to the FRA—something that is borne out in the first stage regressions (see Table S2 in Supporting Information in the online appendix). However, conditional on the rich set of covariates included in the models and our use of the FE estimator to control for time-invariant unobserved heterogeneity, it is highly unlikely that this distance influences households' welfare through any channel except its effects on the household's maize sales to the FRA.

The results of the CF GR-based tests for endogeneity are reported in Table S3 in Supporting Information in the online appendix. We fail to reject the exogeneity of FRA_HH_{idt} at the 10% level in 15 of 16 of the models. The results thus strongly suggest that household maize sales to the FRA are exogenous to household welfare after controlling for the observed covariates and household FE. Therefore, in the Results section below, we focus mainly on the results from the FE regressions; however, the main FE-CF results are reported

[15] Numerous distance-related variables are captured in the RALS data (but not the SS data). Robustness checks indicate that the RALS results are robust to explicitly controlling for these distances (namely, distance to the nearest district town, paved road, feeder road, agricultural marketplace, hammer mill, and agrodealer). We exclude them in the main results reported here because for comparability of the SS and RALS results, it is critical that we specify the models as similarly as possible. However, we report them in Supporting Information in the online appendix. We point the reader to the associated tables in the next section.

[16] Scaling total FRA purchases by the total hectares of maize (or total expected maize quantity harvested) controls for differences across districts in terms of the scale of maize production, and our use of the FE estimator (discussed next) controls for time-invariant differences among districts in terms of geographic size, agro-ecology, etc.

[17] See Wooldridge (2010) for details on the FE estimator.

[18] The household time average for the IV is excluded from the first stage regression because the time average is highly collinear with the IV itself (correlation coefficient of 0.89).

[19] See Mundlak (1978), Chamberlain (1984), and Wooldridge (2010) for details on the CRE approach.

[20] We thus rely on the FE estimates for the SS analysis.

in Table S4 in Supporting Information in the online appendix for completeness.[21]

4 | RESULTS

Table 4 summarizes the results from the main FE regressions, with the SS results in Panel A and the RALS results in Panel B. These results pool all households; later on we present results disaggregated by household MMP. The results are arranged by outcome variable in the rows. Columns (1) and (3) present estimates of the effect of a household's maize sales to the FRA, and columns (2) and (4) present estimates of the effects of an increase in the intensity of FRA maize purchase activity in a district on smallholder household welfare.[22]

The SS-based results indicate that direct participation in FRA's maize purchase program was associated with large, statistically significant welfare improving effects on participating smallholder households' incomes and poverty during the early years of the program. In particular, both the binary and continuous FRA variable specifications suggest that selling maize to the FRA was correlated with higher household total income and per capita income and reductions in the probability of household income falling below the US$1.90 poverty line as well as the household's poverty gap. The binary FRA variable models also suggest that selling maize to the FRA was correlated with lower poverty severity at household level. These income improvements, however, appear not to have translated into greater calorie availability as there is no statistically significant effect of household maize sales to the FRA on calories per AE per day. Similar results generally hold in the RALS data for the poverty-related outcome variables but not for total and per capita income.[23] Rather, in the RALS years, we find no evidence of statistically significant income effects of household maize sales to the FRA. These findings may suggest that in more recent years (i.e., the RALS years), to the extent that household maize sales to the FRA may have raised household incomes, it was mainly among households with incomes below the poverty line. Where statistically significant, the estimated per-kg effects of household maize sales to the FRA in the SS and RALS analyses (column 3) are similar in magnitude. These results are robust to the exclusion of the district-level intensity of FRA maize purchase activity variable[24] and to the inclusion of additional distance-related variables in the RALS models. (See Tables S10 and S11 in Supporting Information in the online appendix.)

A relatively small percentage of Zambian smallholder households directly participate in the FRA's maize purchase program (recall Tables 1 and 2) but the intensity of FRA maize purchase activity in a given area (in this case, district) may affect the welfare of households in that area through its effects on maize (and potentially other) prices and markets. The results in Table 4 suggest that an increase in the intensity of FRA maize purchase activity in a district is associated with quite different effects on smallholder welfare during the early years of the program (i.e., the SS years) versus more recent years (i.e., the RALS years). In particular, across all outcome variables in the SS results (Panel A), we find that an increase in the intensity of FRA activity in a given district is correlated with *reductions* in smallholder welfare (i.e., lower incomes, higher household-level poverty metrics, and lower calorie availability). The opposite is largely the case in the RALS results (Panel B), with increases in the intensity of FRA activity associated with *improvements* in most welfare measures. The direction and statistical significance of these effects are very similar when we use the alternative measure of the intensity of FRA activity in a district (total maize purchased by the FRA as a percentage of total expected maize production in the district). (See Table S12 in Supporting Information in the online appendix.)[25] We explore these effects further below but, in general, these contrasting effects of the intensity of FRA district-level maize purchase activity during the two periods could be due to the FRA's activities having been more disruptive to agricultural markets in the early years of the program (as a new shock to the system) (Mason & Myers, 2013), whereas by the RALS years, the FRA had become a perennial feature of the maize marketing landscape and the system may have reached a new equilibrium. In addition, although still a minority, a significantly larger percentage of smallholder households sold maize to the FRA in the RALS years than in the SS years (e.g., 28% and 22% in the 2011/2012 and 2014/2015 marketing years

[21] We also report in Tables S5–S7 in Supporting Information in the online appendix the first and second stage CF results and associated tests for endogeneity of households maize sales to the FRA that control for distances to other locations and services—variables that are excluded from the main models to retain comparability between the SS and RALS analyses but that further bolster our arguments for the validity of the exclusion restriction for distance to the nearest FRA depot. The results are similar when we include these additional distance variables.

[22] See Tables S8 and S9 in Supporting Information in the online appendix for the full regression results for the binary FRA variable models for the SS and RALS, respectively. Other full regression results are available from the authors upon request.

[23] Recall that we reject exogeneity of the binary FRA variable to poverty severity in the RALS data. The associated FE-CF estimate suggests no statistically significant effect of a household selling maize to the FRA on its poverty severity.

[24] This is consistent with our argument that district-level intensity of FRA maize purchase activity is exogenous to an individual household and thus excluding it from the model should not bias the estimated effect of direct household participation in the FRA maize purchase program.

[25] Similar results are expected given the high correlation between these two measures (0.89 in the SS and 0.93 in the RALS).

TABLE 4 FE estimates of FRA effects on smallholder incomes, poverty, and calorie availability (SS and RALS)

	Coefficient estimates for main explanatory variables			
	Binary FRA variable		Continuous FRA variable	
Outcome variable	= 1 if HH sold maize to FRA	District-level FRA maize purchases (MT/ha of maize)	HH maize sales to FRA (kg)	District-level FRA maize purchases (MT/ha of maize)
Panel A: SS (N = 12,846)	(1)	(2)	(3)	(4)
(a) Gross total income	9,123***	−5,077**	4.235***	−4,697**
	(2,338)	(2,127)	(0.921)	(2,058)
(b) Gross per capita income	626.8*	−683.2***	0.308***	−658.2***
	(324.3)	(252.7)	(0.0930)	(248.4)
(c) Poor (= 1)	−0.0664***	0.0375**	−0.0000161***	0.0338*
	(0.0247)	(0.0182)	(0.00000355)	(0.0181)
(d) Poverty gap	−0.121***	0.0500***	−0.00000780**	0.0419**
	(0.0173)	(0.0166)	(0.00000325)	(0.00166)
(e) Poverty severity	−0.132***	0.0515***	−0.00000445	0.0423**
	(0.0149)	(0.0166)	(0.00000301)	(0.0166)
(f) Calories per AE per day	−106.5	−896.6***	0.000345	−904.2***
	(228.2)	(261.9)	(0.0487)	(265.6)
Panel B: RALS (N = 14,474)				
(a) Gross total income	−133.5	1,788*	−0.190	1,782*
	(1,841)	(978.7)	(2.206)	(925.4)
(b) Gross per capita income	−108.0	592.6*	−0.244	584.3**
	(323.7)	(307.8)	(0.527)	(295.4)
(c) Poor (= 1)	−0.0723***	−0.00512	−0.0000153***	−0.00527
	(0.0179)	(0.00458)	(0.00000256)	(0.00460)
(d) Poverty gap	−0.0780***	−0.00630*	−0.00000879***	−0.00619*
	(0.0119)	(0.00333)	(0.00000147)	(0.00335)
(e) Poverty severity	−0.0719***	−0.00499*	−0.00000580***	−0.00481*
	(0.00982)	(0.00289)	(0.00000107)	(0.00291)

Notes: Income variables are in real 2017 ZMW.

***$p < 0.01$,

**$p < 0.05$,

*$p < 0.10$.

Robust standard errors clustered at the household level in parentheses. All models control for the full set of covariates, and year and province * year dummies. See Tables S8 and S9 in Supporting Information in the online appendix for the full regression results for the binary FRA variable models based on the SS and RALS data, respectively. Gray-shaded cells indicate the RALS model in which we reject exogeneity of household maize sales to the FRA. See Table S4 in Supporting Information in the online appendix for the corresponding FE-CF results.

compared to 10% in the 2007/2008 marketing year). As a result, the benefits of direct FRA participation were more widespread and may have had greater spillover effects on other households and/or the broader economy.

Next, we explore in Table 5 and Table S13, Supporting Information in the online appendix (for the binary and continuous sales to FRA specifications, respectively) how the effects estimated in Table 4 vary across households by their MMP. Recall from Table 1 that the vast majority of households that sell to the FRA are maize net sellers. By definition, maize autarkic households do not sell to the FRA (nor do they buy maize or sell maize to other buyers); a very small share of maize net buyers sell maize to the FRA (zero or virtually zero in the SS years and the first wave of the RALS, and 9% in the second wave of the RALS). For this reason, the only relevant and estimable FRA effects for maize autarkic households in the SS and RALS and for the maize net buyer households in the SS are the effects of the district-level intensity of FRA maize purchase activity. As expected, the estimated effects of household maize sales to the FRA in Table 5 for maize net sellers are similar to the analogous results in the full sample (Table 4), though less precisely measured due to the smaller sample sizes in the disaggregated models. In the RALS years where we can estimate the effects of direct participation in FRA's maize purchase program on maize net buyers, the statistically significant results are

TABLE 5 FE estimates of FRA effects on smallholder incomes, poverty, and calorie availability, by maize market position—binary FRA variable (SS and RALS)

	Coefficient estimates for main explanatory variables					
	Net sellers (N = 3,632)		Autarkic HHs (N = 4,083)		Net buers (N = 5,131)	
Outcome variable	= 1 if HH sold maize to FRA	District-level FRA maize purchases (MT/ha of maize)	= 1 if HH sold maize to FRA	District-level FRA maize purchases (MT/ha of maize)	= 1 if HH sold maize to FRA	District-level FRA maize purchases (MT/ha of maize)
Panel A: SS	(1)	(2)	(3)	(4)	(5)	(6)
(a) Gross total income	8,102*	−7,713	N/A	−3,005**	N/A	−4,678*
	(4,743)	(4,914)		(1,487)		(2,784)
(b) Gross per capita income	782.1	−1,493**	N/A	−328.4	N/A	−492.5
	(731.7)	(723.0)		(263.5)		(330.4)
(c) Poor (= 1)	−0.0783*	0.0761	N/A	0.0521	N/A	0.00877
	(0.0424)	(0.0633)		(0.0374)		(0.0336)
(d) Poverty gap	−0.0717***	0.0216	N/A	0.103***	N/A	0.0831***
	(0.0272)	(0.0423)		(0.0373)		(0.0322)
(e) Poverty severity	−0.0631***	−0.00367	N/A	0.109***	N/A	0.0910***
	(0.0222)	(0.0367)		(0.0390)		(0.0333)
(f) Calories per AE per day	−406.9	−1,026	N/A	−1,766***	N/A	−368.7
	(430.6)	(927.2)		(489.3)		(367.4)
Panel B: RALS	Net sellers (N = 6,791)		Autarkic HHs (N = 3,417)		Net buyers (N = 4,266)	
	(1)	(2)	(3)	(4)	(5)	(6)
(a) Gross total income	−4,868	5,578	N/A	−873.0	−3,072	1,931*
	(3,688)	(5,497)		(710.0)	(7,357)	(1,124)
(b) Gross per capita income	−965.9	1,478	N/A	−153.1	−122.6	335.7**
	(737.6)	(1,362)		(145.4)	(1,529)	(165.7)
(c) Poor (= 1)	−0.0318	0.000684	N/A	−0.00698	−0.0820	0.00230
	(0.0303)	(0.00900)		(0.0105)	(0.156)	(0.00903)
(d) Poverty gap	−0.0534***	−0.00232	N/A	−0.0122	−0.204**	0.000679
	(0.0167)	(0.00472)		(0.0100)	(0.0908)	(0.00702)
(e) Poverty severity	−0.0481***	−0.00264	N/A	−0.0113	−0.205***	−0.00103
	(0.0129)	(0.00335)		(0.00925)	(0.0658)	(0.00588)

Notes: Income variables are in real 2017 ZMW.

***$p < 0.01$,

**$p < 0.05$,

*$p < 0.10$. Robust standard errors clustered at the household level in parentheses. All models control for the full set of covariates, and year and province * year dummies.

similar to but larger in magnitude for maize net buyers than for maize net sellers (Table 5, Panel B). Moreover, the results disaggregated by MMP suggest that the welfare reducing effects of more intense FRA maize purchase activity in a district during the SS years are almost entirely borne by maize autarkic and maize net buying households as one would expect. Finally, when we disaggregate by MMP, we find very limited evidence in the RALS years (solely among net buyers) of statistically significant associations between the intensity of FRA activity and smallholder welfare.

As a final exercise, we explore in Table 6 some potential pathways through which household maize sales to the FRA and more intense FRA maize purchase activity in an area may affect smallholder welfare by analyzing the effects on different income sources: maize income, non-maize crop income, and other (non-crop) income. As expected, most of the effect of direct participation in the FRA maize purchase program on household incomes comes through a positive effect on maize income (Table 6). In the RALS years, this is the only income component that is affected but in the SS years, there appear to also have positive effects on other (non-crop) income. One possible explanation for this is that households that sell to the FRA use some of the additional maize income they earn to invest in livestock production or off-farm activities such

TABLE 6 FE estimates of FRA effects on smallholder sources of income (SS and RALS)

	Coefficient estimates for main explanatory variables			
	Binary FRA variable		Continuous FRA variable	
Outcome variable	=1 if HH sold maize to FRA	District-level FRA maize purchases (MT/ha of maize)	HH maize sales to FRA (kg)	District-level FRA maize purchases (MT/ha of maize)
Panel A: SS ($N = 12{,}846$)	(1)	(2)	(3)	(4)
(a) Maize income	6,092***	−246.3	2.523***	26.91
	(696.1)	(510.6)	(0.338)	(401.6)
(b) Non-maize crop income	−320.6	−1,133***	0.365	−1,180***
	(369.0)	(246.9)	(0.355)	(232.6)
(c) Other (non-crop) income	3,352*	−3,697*	1.347**	−3,544*
	(1,972)	(1,969)	(0.585)	(1,973)
Panel B: RALS ($N = 14{,}474$)				
(a) Maize income	2,181***	−23.80	1.465***	17.59
	(316.1)	(62.50)	(0.134)	(57.72)
(b) Non-maize crop income	213.7	184.2***	−0.00746	182.8***
	(156.7)	(40.70)	(0.0407)	(40.60)
(c) Other (non-crop) income	−2,528	1,628*	−1.648	1,582*
	(1,777)	(988.6)	(2.205)	(922.9)

Notes: Income variables are in real 2017 ZMW.
***$p < 0.01$,
**$p < 0.05$,
*$p < 0.10$. Robust standard errors clustered at the household level in parentheses. All models control for the full set of covariates, and year and province * year dummies.

as small business activities later in the marketing year. To explore this, we ran FE regressions analogous to Equation (1) but with livestock income and business income as the dependent variables, and found that the direct FRA effect is positive and statistically significant at the 10% level for both. Households may also invest some of this income in maize or other crop production in the following agricultural year but this is not something we can estimate with the SS and RALS data given the time periods covered. (See Supporting Information in the online appendix for details).

The results in Table 6 also suggest that in both the SS and RALS periods, the effects of more intense FRA maize purchase activity in a district on smallholder incomes come through income sources other than maize: other (non-crop) income and, to a lesser extent, non-maize crop income. As in Table 4, these effects suggest negative income effects during the SS period, and positive ones during the RALS period. We are limited by the data available in the SS and RALS in the extent to which we can further explore what is driving these divergent district-level FRA intensity results in the two datasets. One potential explanation (which could be tested more rigorously in future research using other data if available) is that the maize market price raising and market distorting effects of the FRA maize purchase program during the early (SS) years (such as those documented in Mason and Myers (2013)) and the very narrow and concentrated participation of smallholders in the program (see Table 2) may have adversely affected many smallholders' purchasing power during that period, which may have translated into lower demand for non-maize crops, livestock, or local good and services. This, in turn, may have resulted in lower non-maize crop income and other (non-crop income) for many smallholder households. FE regressions indeed suggest negative correlations between more intense FRA activity and wage income in particular (but no effects on livestock or business income). In contrast, by the RALS years, Zambian maize markets may have adjusted to the perennial involvement of the FRA and its market distorting effects may have been less dramatic or better anticipated by various market actors. In addition, although still relatively narrow, smallholder participation in the FRA's maize purchase program was significantly broader and less concentrated in the RALS years and higher incomes among participating households below the poverty line (see Table 4, Panel B) might have translated into greater demand for other crops, livestock, and local good and services, raising smallholder incomes from these activities. Indeed, auxiliary FE regressions with the RALS data suggest positive associations between the intensity of FRA activity and both livestock and business income (but not wage income).

5 | CONCLUSIONS

Since the early 2000s, there has been a renewed interest among African policymakers in using crop purchase programs to raise incomes and reduce poverty among smallholder

farmers. However, to date, there is limited empirical evidence on such programs' welfare effects. This paper studies the welfare effects of the Zambian FRA's maize purchase program on smallholder households using two nationally representative household panel survey data sets spanning a total of 15 years (the SS, covering the 2000/2001, 2003/2004, and 2007/2008 marketing years, and the RALS, covering the 2011/2012 and 2014/2015 marketing years).

Overall, our results indicate that maize sales to the FRA are correlated with improvements in most household-level poverty outcomes among households that sell to the FRA. Almost all of these households are maize net sellers. These findings hold during both the early (SS) and more recent (RALS) years of the FRA's involvement in Zambian maize markets. While households that sell maize to the FRA may benefit from doing so (on average), even at the height of the FRA's activities in 2011/2012, it was still only a fraction of Zambian smallholders (28%) that sold maize to the FRA and directly benefited from the typically above-market prices offered by the Agency; moreover, smallholder maize sales to the FRA were highly concentrated among those with more land (Mason et al., 2015; Table 2). And although we find evidence that selling maize to the FRA is associated with improved poverty outcomes for participating households, the cost-effectiveness of FRA's maize purchase program as a poverty reduction tool is very much an open question and an area for future research. Furthermore, more intense FRA maize purchase activity in a district was associated with lower welfare for maize autarkic and maize net buying households during the early years of the program. And while we do not find evidence of these negative welfare effects in more recent years, we find only limited evidence that these households indirectly benefited from the program during this period (with positive income effects noted only for net buyers (Table 5)).

Taken together, this paper shows that the smallholder welfare effects of a crop purchase program can be both positive and negative, and can also vary significantly over time, from the program's first entry to when it becomes an established player in the market. These heterogeneous effects had not been previously empirically estimated in the literature on crop purchase programs in SSA and should be taken into account as governments consider implementing new or reforming existing crop purchase programs with the goal of improving smallholder farmer welfare.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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