Smallholder Behavioral Responses to Marketing Board Activities in a Dual Channel Marketing System: The Case of Maize in Zambia

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International Association of Agricultural Economists Triennial Conference
Foz do Iguaçu, Brazil, 19 August 2012

I. INTRODUCTION

• Resurgence of direct state involvement in agricultural markets in ESA:
  – Large-scale government fertilizer subsidy programs
  – Large purchases of grain by parastatal grain marketing boards (GMBs) and strategic grain reserves (SGRs)
  – E.g., Zambia, Malawi, Kenya, Tanzania, Zimbabwe, Ethiopia

• Private grain trade remains legal → dual marketing channels (gov’t & private sector)

• Increasingly important feature of grain markets in ESA
  → How are smallholders responding?
  → How to model?
Contributions

1. **Conceptual model** of farmer production decisions in dual channel marketing system

2. **Empirical application** – Zambia
   - Food Reserve Agency (FRA)
   - Strategic food reserve/maize marketing board
   - Dominant single buyer of maize (>80%)
   - FRA price > market price
   - Nationally-representative HH panel survey data

Research questions

**Past FRA policies:**
- Purchase price
- Quantities purchased

? → **Farmer’s expected maize price**

? → **Farmer’s production decisions:**
- More maize? Intensification and/or extensification?
- Effects on other crops?
I. Introduction

ZAMBIA

- Landlocked (≈Texas)
- Population: 13 million (61% rural)
- GDP/cap (PPP): US$1,600 (24/48 in SSA)
- Rural poverty rate: 78%
- Agriculture: 85% of labor force
- Maize:
  - ~ 60% of calories
  - ~ 80% of smallholders grow

Sources: CIA World Factbook (2011 estimates for GDP, labor force), 2010 Census (population), 2010 Living Conditions Monitoring Survey (poverty rate)
Established in 1996

**Strategic mission**: ensuring national food security and incomes

One of Zambia’s flagship ag-sector poverty reduction programs (other is fertilizer subsidies)

Changes over time in procurement practices & scale

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**FRA share of smallholder marketed maize**

Sources: FRA; CSO/MACO Crop Forecast & Post-Harvest Surveys
III. Conceptual model

Key assumptions & stylized facts

1. **Unknown at planting time**: FRA maize price, depot locations, target purchase quantities; market prices for maize, other crops

2. FRA price not a floor price

3. FRA price pan-territorial at depots; farmgate price varies across HHs (transportation costs)

4. Risk-neutral, expected profit-maximizing producer
Factor demand & output supply functions

\[ y = y[p^*, E(p_o), w; z] \]

where:
- \( y \) = input & output quantities
- \( p^* \) = expected farmgate maize price
- \( E(p_o) \) = expected prices for other crops
- \( w \) = variable input prices
- \( z \) = other production shifters

\[ p^* = Pr(\gamma = 1)E[\max(p_f, p_p)] + [1 - Pr(\gamma = 1)]E(p_p) \]

where:
- \( p_f \) = farmgate maize price at harvest, \( j = f \) (FRA), \( p \) (private sector)
- \( \gamma = 1 \) if FRA channel available at harvest, =0 o.w.

III. Conceptual model

IV. Data

- Nationally-representative HH panel survey
  - 394 enumeration areas (map)
  - Smallholder HHs (cultivate <20 ha)
  - Farm & non-farm activities, demographics, assets, sales to FRA
  - Wave 1: 1999/2000 (6,922 HHs)
    - FRA had not bought maize since October 1997
  - Wave 2: 2002/2003 (5,358 HHs, 77% of wave 1)
    - 1st year FRA bought directly from smallholders (24,000 MT)
  - Wave 3: 2006/2007 (4,286 HHs, 80% of wave 2)
    - FRA scaled up (390,000 MT)
- Data from FRA on prices, purchases
$y = y[p^*, E(p_o), w; z]$

where $p^* = \text{Pr}(\gamma = 1)E[\max(p_f, p_p)] + [1-\text{Pr}(\gamma = 1)]E(p_p)$

1. Bivariate lognormality $\rightarrow E[\max(p_f, p_p)]$ is function of
   - Means: $E(\ln p_f), E(\ln p_p)$
   - Variances: $\text{Var}(\ln p_f), \text{Var}(\ln p_p)$
   - Covariance: $\text{Cov}(\ln p_f, \ln p_p)$

2. Estimate these and $\text{Pr}(\gamma = 1)$ as function of past FRA policies, other factors

3. Construct $p^*$; compute partial effects of FRA policies on $p^*$

4. Estimate factor demand/output supply functions including $p^*$ as regressor

5. Chain rule to compute partial effects of FRA policies on factor demand/output supply
Estimating subjective values for $E(\ln p_j), j = p, f$

$$\hat{E}(\ln p_{j,i,t}) = X_{i,t-1}\hat{\beta}_j$$

where:

*i* indexes HH, *t* indexes time

$p_{i,j,t} =$ farmgate price at harvest time

$X_{i,t-1} =$ info observed at planting time (e.g., past FRA & private sector farmgate prices, past FRA purchases, etc.)

- CRE-POLS (time invariant heterogeneity)
- Similar strategy for $Var(\ln p_j)$
- Assume constant $Corr(\ln p_f, \ln p_p) \rightarrow$ derive $Cov(\ln p_f, \ln p_p)$

Estimating subjective values for $Pr(\gamma=1)$

CRE-Probit:

$$\tilde{Pr}(\gamma_{i,t} = 1 | X_{i,t-1}) = \Phi(X_{i,t-1}\hat{\omega})$$

where:

$\gamma_{i,t} = 1$ if HH sold to FRA at harvest; $= 0$ o.w.

$\Phi =$ standard normal CDF

$X_{i,t-1} =$ info observed at planting time (e.g., past FRA & private sector farmgate prices, past FRA purchases, etc.)

→ Construct expected maize price, $\hat{p}_{i,t}^*(X_{i,t-1})$

→ Compute partial effects of past FRA policies on $\hat{p}_{i,t}^*$
Empirical factor demand & output supply equations

\[ y_{i,t} = \alpha_0 + \alpha_1 \hat{p}_{i,t} + p_{o,i,t-1} \alpha_2 + w_{i,t} \alpha_3 + z_{i,t} \alpha_4 + c_i + u_{i,t} \]

where:

- \( y_{i,t} \) = fertilizer app. rate; maize/other crops area, yield, qty harvested
- \( \hat{p}_{i,t} \) = est. expected maize price; \( p_{o,i,t-1} \) = lagged prices other crops
- \( w_{i,t} \) = variable input prices (fertilizer, ag wage)
- \( z_{i,t} \) = other shifters (HH characteristics, kg of subsidized fertilizer rec’d)
- \( c_i \) = time invariant heterogeneity; \( u_{i,t} \) = time-varying error term

- Fixed effects or CRE-Tobit
- Control function for subsidized fertilizer (Ricker-Gilbert et al., 2011)
- Bootstrap standard errors

V. Empirical models & estimation strategy 16

VI. Results
< 10% sell to FRA; sellers relatively better off

Smallholder characteristics by participation in FRA, 2006/07 agricultural year

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Sold maize to FRA?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>% of smallholders</td>
<td>9.7%</td>
</tr>
<tr>
<td>Landholding size (ha)</td>
<td>3.65</td>
</tr>
<tr>
<td>Real value of farm assets (mil Kwacha)</td>
<td>6.57</td>
</tr>
<tr>
<td>Median education of head (highest grade)</td>
<td>7</td>
</tr>
<tr>
<td>% female-headed</td>
<td>14.0%</td>
</tr>
</tbody>
</table>

Source: 2008 CSO/MACO/FSRP Supplemental Survey

↑ lagged FRA price → ↑ expected maize price

Average elasticity of expected maize price w.r.t. FRA policies, 2006/07 agricultural year

<table>
<thead>
<tr>
<th>FRA policy</th>
<th>Average elasticity</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRA farmgate price (t-1)</td>
<td>0.088</td>
<td>0.01</td>
</tr>
<tr>
<td>FRA district-level purchases (t-1)</td>
<td>0.055</td>
<td>0.17</td>
</tr>
</tbody>
</table>

Source: Authors’ calculations
Dependent variable | Average elasticity w.r.t. expected maize price | p-value | Average elasticity w.r.t. lagged FRA price (2006/07)
--- | --- | --- | ---
Fertilizer application rate | 0.74 | 0.01 | 0.14
Maize area planted | 0.67 | 0.02 | 0.06
Maize yield | --- | 0.25 | ---
Maize quantity harvested | 0.67 | 0.02 | 0.06

Source: Authors’ calculations

- No stat. sig. effects on other crops

VI. Results

HHs with larger landholdings are more responsive to FRA price & sell more to FRA

<table>
<thead>
<tr>
<th>Landholding size (cultivated + fallow)</th>
<th>% of small-holder HHs</th>
<th>Estimated Δ in maize quantity harvested per Δ in lagged FRA price</th>
<th>% selling maize to FRA</th>
<th>% of total smallholder maize sold to FRA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Elasticity</td>
<td>Kg per 100 ZMK/kg</td>
<td>(E)</td>
</tr>
<tr>
<td>0-0.99 ha</td>
<td>37.6%</td>
<td>0.047</td>
<td>4.3</td>
<td>2.2%</td>
</tr>
<tr>
<td>1-1.99 ha</td>
<td>32.7%</td>
<td>0.056</td>
<td>8.5</td>
<td>7.9%</td>
</tr>
<tr>
<td>2-4.99 ha</td>
<td>24.3%</td>
<td>0.069</td>
<td>19.3</td>
<td>15.8%</td>
</tr>
<tr>
<td>5+ ha</td>
<td>5.4%</td>
<td>0.082</td>
<td>41.2</td>
<td>28.1%</td>
</tr>
<tr>
<td>Overall</td>
<td>100.0%</td>
<td>0.060</td>
<td>13.21</td>
<td>9.7%</td>
</tr>
</tbody>
</table>

Note: ZMK = Zambian Kwacha
Source: Authors’ calculations, 2006/07 agricultural year
Conclusions

1. Increase in FRA price raises smallholder’s expected maize price
   → Maize intensification (higher fertilizer app. rate)
   → Maize extensification (area expansion)
   → No stat. sig. effects on other crops

2. Smallholders w/ larger landholdings (proxy – higher incomes) benefit most
   – More responsive to changes in FRA price
   – Largest 5% account for >50% of sales to FRA

VI. Conclusions & policy implications

Policy implications

• FRA has stimulated a maize supply response. Large enough to justify massive expenditures?
  – 2010: 7% of total government spending, 2% of GDP (IMF, 2012)
• Did not estimate direct or general equilibrium effects on poverty or food security per se BUT the concentration of benefits of FRA in hands of a few relatively wealthy smallholders casts doubt on the:
  1. Poverty-reduction efficacy of FRA (rural poverty rate unchanged at 78%, 2004 & 2010)
  2. FRA’s achievement of its strategic mission (“ensure national food security and incomes”)
• Limit FRA purchases to strategic reserve quantities → invest in known drivers of pro-poor agricultural growth - R&D, extension, infrastructure, education (Fan et al., 2008; Economist Intelligence Unit, 2008)
Thank you! Questions or comments?
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