General equilibrium effects of input subsidy programs on maize prices: Evidence from Malawi and Zambia.

J. Ricker-Gilbert
N.M. Mason
T.S. Jayne
F.A. Darko
S. Tembo

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Subsidized fertilizer by year - Malawi

![Bar chart showing subsidized fertilizer by year in Malawi.]
Official maize production by year – Malawi
Subsidized fertilizer & real retail maize prices (harvest season) - Malawi

Subsidized fertilizer (MT)

Real retail maize price (MK/kg)

- 1999/2000
- 2000/2001
- 2001/2002
- 2002/2003
- 2003/2004
- 2004/2005
- 2005/2006
- 2006/2007
- 2007/2008
- 2008/2009
- 2009/2010
- 2010/2011

Subsidized fertilizer (MT)

Real retail maize price (MK/kg, Oct. 2011=100)
Potential reasons for high maize prices in Malawi when subsidy was scaled up (Dorward, Chirwa & Jayne 2010)

1) National maize production estimates overstated.
2) Increased exports by Malawian government, and purchases for strategic grain reserve.
3) Increased household income
   – NSO 2012, rural poverty rates constant
4) Increased storage loss resulting from increased use of hybrid maize.
5) Rising world food prices, and Malawi remaining at import parity relative to neighboring countries.
   - Malawi imported from Mozambique in most months
Subsidized fertilizer & real retail maize prices (harvest season) - Zambia
Research Question/Testable Hypothesis

• How does an increase in subsidized fertilizer distributed to a district affect maize prices in that district?

• To our knowledge this has yet to be empirically estimated.
Why does the impact of subsidized fertilizer on maize prices matter?

• Huge public expenditure on subsidized fertilizer.
  – 7 countries spending US $2 billion in 2012 (Ricker-Gilbert et al. 2013)

• States goals are to increase fertilizer use, boost staple crop production, improve food security, & reduce poverty.

• Urban consumers and majority of rural poor are net buyers of maize.

Ability of subsidy programs to lower maize prices could have positive welfare implications for millions of HH in sub-Saharan Africa.
## Data

### Malawi

<table>
<thead>
<tr>
<th>Variable</th>
<th>Data</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize prices</td>
<td>Weekly retail: 72 markets in 26 districts</td>
<td>Min of Ag. &amp; Food Security</td>
</tr>
<tr>
<td>Subsidized fertilizer MT</td>
<td>Annual district allocation</td>
<td>Logistics Unit Reports</td>
</tr>
</tbody>
</table>

### Zambia

<table>
<thead>
<tr>
<th>Variable</th>
<th>Data</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize prices</td>
<td>Weekly retail: 50 districts</td>
<td>Central Statistics Office</td>
</tr>
<tr>
<td>Subsidized fertilizer MT</td>
<td>Annual district allocation</td>
<td>Min of Ag &amp; Coops</td>
</tr>
</tbody>
</table>

Conceptual Framework

Framework for understanding how subsidy program may affect maize prices.

- Increase in total fertilizer use
  - Commercial fertilizer use
  - Subsidized fertilizer use

- Increase in maize production
  - Risk aversion
  - Soil management

- Decrease in maize prices

Degree of market integration

General equilibrium effects

Supply response

Crowding out
Previous Literature in Malawi and Zambia

• HH-level data shows that subsidized fertilizer crowds out commercial fertilizer in both countries.
  – (Jayne et al. this issue)

• HH level data suggest that production increases are positive but modest.
  – Zambia (Mason & Jayne Forthcoming).

• Previous literature shows markets in region reasonably well-integrated.
1) **Maize output supply**

\[ Q_s = Q^S(p_f^*, FISP, z^s) \]

- \( Q_s \), maize qty produced
- \( p_f^* \), expected producer price
- FISP, qty of subsidized fertilizer
- \( z^s \), vector of supply shifters

2) **Retail maize demand**

\[ Q_d = Q^d(p_r, z^d) \]

- \( Q_d \), maize qty demanded
- \( p_r \), retail maize price
- \( z^d \), vector of demand shifters

3) **Retail maize price**

\[ p_r = p_f^* + M(z^m) \]

- \( p_f^* \) realized producer prices
- \( z^m \), vector of factors affecting marketing margins

4) **Market clearing condition**

\[ Q_t^d = Q_t^s \]

5) **Retail price equation**

\[ p_r = p_r(p_f^*, FISP, z^s, z^d, z^m) \]
Empirical Specification

Retail maize price for district $i$ in season $t$: 

$$ p_{i,t}^r = \Psi + \alpha FISP_{i,t} + \sum_{j=0}^{J} \Upsilon_j p_{i,t-j}^r + X_{i,t} \beta + Z_t \theta + c_i + \mu_{i,t} $$

- $c_i =$ time-constant errors
- $\mu_{i,t} =$ time-varying errors

$H_0: \hat{\alpha} = 0; \text{ test if subsidized fertilizer affects maize prices}$

$$ \frac{\hat{\alpha}}{1 - \sum_{j=1}^{J} \hat{\Upsilon}_j} = \text{long-run impact of subsidized fertilizer on maize prices} $$
Estimate model via First-Difference

$$\Delta p_{i,t} = \Psi + \alpha \Delta FISP_{i,t} + \sum_{j=0}^{J} \gamma_j \Delta p_{i,t-j}^r + \Delta X_{i,t} \beta + \Delta Z_t \theta + \Delta \mu_{i,t}$$

- FD estimation removes $c_i$ from model

- $\Delta p_{i,t-j}^r$ correlated with $\Delta \mu_{i,t}$ since $\Delta p_{i,t-1}^r$ depends on $\mu_{i,t-1}$

- Use $\Delta p_{i,t-j}^r$ for $j \geq 2$ as instrumental variable for $\Delta p_{i,t-j}^r$

- This is the Arellano-Bond Estimator (Arellano and Bond 1991)

- Include enough lags of $p_{i,t}^r$ as necessary to remove serial correlation.
  - 3 lags for Malawi
  - 8 lags for Zambia

- Estimate separate models for Malawi and Zambia.

- 2 observations per market, per year, (harvest and lean)
Variables included in X and Z

### District-level variables (X)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real retail rice prices</td>
<td>Malawi &amp; Zambia</td>
</tr>
<tr>
<td>Real retail bread prices</td>
<td>Zambia</td>
</tr>
<tr>
<td>Marketing board purchases</td>
<td>Zambia</td>
</tr>
<tr>
<td>Growing season rainfall</td>
<td>Malawi &amp; Zambia</td>
</tr>
<tr>
<td>Rainfall stress</td>
<td>Malawi &amp; Zambia</td>
</tr>
<tr>
<td>District dummies</td>
<td>Malawi &amp; Zambia</td>
</tr>
<tr>
<td>Diesel prices</td>
<td>Zambia</td>
</tr>
</tbody>
</table>

### National-level variables (Z)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel prices</td>
<td>Malawi</td>
</tr>
<tr>
<td>Lending rate</td>
<td>Zambia</td>
</tr>
<tr>
<td>Electricity rate</td>
<td>Zambia</td>
</tr>
<tr>
<td>Zambia border prices</td>
<td>Malawi</td>
</tr>
<tr>
<td>Malawi border prices</td>
<td>Zambia</td>
</tr>
<tr>
<td>South Africa Commodity Exchange (SAFEX) maize prices</td>
<td>Malawi &amp; Zambia</td>
</tr>
</tbody>
</table>

We also include, year dummies, lean season dummy, and a linear time trend.
## Results - Malawi

### Factors affecting log of real retail maize prices at the market level

<table>
<thead>
<tr>
<th>Explanatory Variables</th>
<th>Sparse Model</th>
<th>Full Model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A) FD</td>
<td>B) AB</td>
</tr>
<tr>
<td>Subsidized fertilizer ('000 MT)</td>
<td>-0.003*</td>
<td>-0.003*</td>
</tr>
<tr>
<td>Rainfall variables</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Other controls</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Lagged maize prices?</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Marketing year dummies?</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Time period dummies?</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Long-run effect of subsidized fertilizer</td>
<td>N/A</td>
<td>-0.004</td>
</tr>
<tr>
<td>Observations</td>
<td>1,112</td>
<td>969</td>
</tr>
<tr>
<td>Overall model F-test for FD, Wald test for AB</td>
<td>2,615***</td>
<td>26,875***</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.80</td>
<td>N/A</td>
</tr>
</tbody>
</table>

*, **, *** denotes that corresponding coefficients are statistically significant at the 10%, 5% and 1% level respectively.
## Results - Zambia

### Factors affecting log of real retail maize prices at the district level

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<tbody>
<tr>
<td></td>
<td>A) FD</td>
<td>B) AB</td>
</tr>
<tr>
<td>Subsidized fertilizer ('000 MT)</td>
<td>-0.024**</td>
<td>-0.019***</td>
</tr>
<tr>
<td>Rainfall variables</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Other controls</td>
<td>No</td>
<td>No</td>
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<td>Time period dummies?</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Long-run effect of subsidized fertilizer</td>
<td>N/A</td>
<td>-0.024***</td>
</tr>
<tr>
<td>Observations</td>
<td>1,145</td>
<td>745</td>
</tr>
<tr>
<td>Overall model F-test for FD, Wald test for AB</td>
<td>491***</td>
<td>17,381***</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.80</td>
<td>N/A</td>
</tr>
</tbody>
</table>

*, **, *** denotes that corresponding coefficients are statistically significant at the 10%, 5% and 1% level respectively.
Conclusions

• In Malawi between 1999 – 2011, average district received 4,373 MT of fertilizer
  – Doubling program reduces maize price by 1.2% to 1.6% on average
• In Zambia between 1999 – 2012, average district received 1,108 MT of fertilizer
  – Roughly doubling program reduces maize price by 1.8% to 2.4% on average
• Results robust to different specifications
  - real prices, level-level
  - nominal prices, log-log
  - nominal prices, level-level
Conclusions continued

• Findings are consistent with household-level data showing small increases in maize production from subsidy.
  – Malawi and Zambia at import parity. Local production increases likely just off-set imports. No effect on local prices.

• Consistent with government reports that rural poverty rates have not dropped in Malawi or Zambia over the past 10 years.

• Even small decreases in maize price can help poor.
  - but if these economies are reasonably well integrated into regional markets, should not expect to see large changes in maize price.
Thank you for your time!

jrickerg@purdue.edu
masonn@msu.edu
jayne@msu.edu
fdarko@purdue.edu
Solomon.tembo@iapri.org.zm

Questions/Comments are appreciated