What are the effects of input subsidy programs on maize prices? Evidence from Malawi and Zambia.

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Subsidized fertilizer by year - Malawi
Official maize production by year – Malawi
Subsidized fertilizer by year - Zambia
Subsidized fertilizer & real retail maize prices (harvest season) - Zambia

Subsidized fertilizer (MT)

Real retail maize price (ZMK/kg, Apr. 2012=100)
Research Question/Testable Hypothesis

- How does an increase in the quantity of subsidized fertilizer distributed affect maize prices?

- Very little empirical evidence to date
Why does the impact of subsidized fertilizer on maize prices matter?

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

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

• **Direct** impacts on subsidy recipients

• **Indirect** impacts on recipients & non-recipients through lower maize prices?
  – Urban consumers and most rural poor are net buyers
  – Claims of massive spillovers & poverty reduction impacts
Conceptual Framework

Pathways of subsidy program effects on maize prices.

- Increase in total fertilizer use
  - Commercial fertilizer
  - Increase in subsidized fertilizer
  - Crowding out

- Soil, weather management
  - Risk aversion
  - Increase in maize production

- Supply response

- Higher marketed supply
- Lower demand (self-sufficiency)
- Decreased maize prices

- Degree of market integration
- Import/export parity position

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Previous Literature in Malawi and Zambia

• Subsidized fertilizer crowds out commercial fertilizer
  – Malawi (Ricker-Gilbert et al. 2011)
  – Zambia (Mason & Jayne 2013)

• Subsidized fertilizer increases maize production but effects are small
  – Malawi (Holden & Lunduka 2010; Ricker-Gilbert & Jayne 2011; Shively et al. 2012)
  – Zambia (Mason et al. 2013)

• Markets in the region are reasonably well-integrated

• Malawi at import parity during most of study period

→ *A priori, don’t expect large subsidy effects on prices*
Economic model

1) Maize output supply
\[ Q^s = Q^s(p^f*, FISP, z^s) \]
- \( Q^s \), maize qty supplied
- \( p^f* \), 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 price – producer price relationship
\[ p^r = p^f + M(z^m) \]
- \( p^r \), retail maize price
- \( p^f \), realized producer price
- \( z^m \), vector of marketing margin shifters

4) Market clearing condition
\[ Q^d = Q^s \]

5) Reduced form of retail price as function of subsidized fertilizer
\[ p^r = p^r(p^f*, FISP, z^s, z^d, z^m) \]
## Data

### Malawi

<table>
<thead>
<tr>
<th>Variable</th>
<th>Data</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail maize prices</td>
<td>Monthly, 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>
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</table>

### Zambia

<table>
<thead>
<tr>
<th>Variable</th>
<th>Data</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail maize prices</td>
<td>Monthly, 50 districts</td>
<td>Central Statistical Office</td>
</tr>
<tr>
<td>Subsidized fertilizer MT</td>
<td>Annual district allocation</td>
<td>Min. of Ag. &amp; Livestock</td>
</tr>
</tbody>
</table>

Empirical model

\[ p_{i,t}^r = \psi + \alpha FISP_{i,t} + \sum_{j=0}^{J} \gamma_j p_{i,t-j}^r + X_{i,t} \beta + Z_t \theta + c_i + u_{i,t} \]

- \( p_{i,t}^r \) = Retail maize price in market/district \( i \) at time \( t \)
- \( \psi \) = time-constant error
- \( \alpha \) = Long-run impact of subsidized fertilizer on maize prices
- \( FISP_{i,t} \) = Qty of subsidized fertilizer allocated to the district
- \( \gamma_j \) = Lagged retail maize price
- \( X_{i,t} \) = District-National/international level S/D/MM shifter
- \( Z_t \) = S/D/MM shifters
- \( \beta \) = time-varying error
- \( c_i \) = time-constant error
- \( u_{i,t} \) = time-varying error

Test if subsidized fertilizer affects maize prices

\[ H_0 : \alpha = 0 \]
### Variables included in X and Z

<table>
<thead>
<tr>
<th>District-level variables (X)</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>Malawi &amp; 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 (dry spells)</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>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>National-level variables (Z)</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel prices</td>
<td>Malawi</td>
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<tr>
<td>Commercial interest rate</td>
<td>Zambia</td>
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<tr>
<td>Electricity prices</td>
<td>Zambia</td>
</tr>
<tr>
<td>Zambia border maize prices</td>
<td>Malawi</td>
</tr>
<tr>
<td>Malawi border maize prices</td>
<td>Zambia</td>
</tr>
<tr>
<td>Northern Mozambique maize prices</td>
<td>Malawi</td>
</tr>
<tr>
<td>South African Futures Exchange (SAFEX) maize prices</td>
<td>Malawi &amp; Zambia</td>
</tr>
</tbody>
</table>

Also include: year dummies, lean season dummy, year dummies * lean season dummy, & a linear time trend
Estimation strategy

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

- **First-difference (FD)** estimation removes \( c_i \) (omit LDV)
- **Arellano-Bond (AB)** to estimate dynamic panel data model (with LDV)

- Separate models for Malawi and Zambia
- 2 observations per market/district per year
  - Harvest season (May-Oct.)
  - Lean season (Nov.-Apr.)

- Explored possible subsidized fertilizer **spatial spillovers**:
  - Kg to neighboring districts only
  - Kg to all other districts, weighted by inverse distance between districts \( i \) and \( j \)
  - No evidence of spatial spillovers
### Factors affecting log 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>
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<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>Time dummies &amp; time trend?</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>
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<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>2,616***</td>
<td>26,668***</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 real retail maize prices at the district level

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<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>-0.028**</td>
<td>-0.020***</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>Time dummies &amp; time trend?</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Long-run effect of subsidized fertilizer</td>
<td>N/A</td>
<td>-0.030***</td>
</tr>
<tr>
<td>Observations</td>
<td>1,145</td>
<td>745</td>
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<tr>
<td>Overall model F-test for FD, Wald test for AB</td>
<td>448***</td>
<td>20,697***</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
How large are these price effects?

• Roughly doubling the program size in every district reduces prices by an average of:
  – 1.2% to 1.6% in Malawi
  – 2.0% to 2.8% in Zambia

• Statistically significant but small-in-magnitude price reduction
Malawi: 1.6% reduction in price generates a CS gain of US $3.32 million per year.
  = 2.4% of average total program cost per year.
Zambia: 2.8% reduction in price generates a CS gain of US $5.81 million per year.
  = 5.2% of average total program cost per year.

Even small decreases in maize price can help poor.
But price effects insufficient to justify program costs
Conclusions

• Subsidized fertilizer - small negative effect on prices

• Findings consistent with previous studies showing:
  – Subsidized fertilizer crowds out commercial fertilizer
  – Small increases in maize production from subsidy

• Malawi: at import parity most of the time. Local production increases likely just off-set imports.

• Zambia: favorable rainfall & marketing board activities also raised maize production, not just FISP.

• Markets in both countries fairly well-integrated → price effects small & short-lived
Conclusions (continued)

• Little support for claim that large expenditures warranted because fertilizer subsidy programs have massive spillover effects and reduce poverty by reducing maize prices
Thank you for your time!

Questions/Comments are appreciated

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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 (2008), 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
Estimation strategy

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

• FD removes \( c_i \) from model

• \( \Delta p_{i,t-1}^r \) correlated with \( \Delta u_{i,t} \) since \( \Delta p_{i,t-1}^r \) depends on \( u_{i,t-1} \)

• Use \( p_{i,t-j}^r \) for \( j \geq 2 \) as instrumental variables for \( \Delta p_{i,t-1}^r \)

• This is the Arellano-Bond Estimator, for dynamic panel models (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
How large are these price effects?

- In Malawi between 1999 – 2011, average district received 4,373 MT of fertilizer
  - Roughly doubling program size in every district 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 size in every district reduces maize price by 2.0% to 2.8% on average
- Statistically significant but small-in-magnitude price reduction