How do fertilizer subsidy programs affect total fertilizer use in sub-Saharan Africa?

Crowding out, diversion, & benefit/cost assessments

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conference on Economic Development in Africa
St. Catherine’s College, University of Oxford

Motivation

• Dr. Liverpool-Tasie reviewed the basic framework and motivation for studying crowding in/out → what is $\delta_{total}/\delta_{govt}$?

• Substantial % of fertilizer intended for input subsidy programs (ISPs) is illegally diverted and sold to farmers at/near market prices
Fertilizer intended for distribution through ISP (govt) -> Farmers

Fertilizer imported/produced for private sector/commercial sales (comm) -> Fertilizer retailers (formal & informal)

Fertilizer retailers (formal & informal) -> Farmers

nondistributed diverted

allcomm = comm + diverted

Fertilizer imported/produced for private sector/commercial sales (comm) -> Fertilizer retailers (formal & informal)
Evidence of diversion: Zambia

<table>
<thead>
<tr>
<th>Agricultural Year</th>
<th>MT of ISP fertilizer delivered to districts based on Ministry of Agriculture &amp; Livestock (MAL) records</th>
<th>MT of ISP fertilizer received as such by farmers based on HH survey data (% of MAL quantities)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002/2003</td>
<td>48,000</td>
<td>31,722 (66%)</td>
</tr>
<tr>
<td>2003/2004</td>
<td>60,000</td>
<td>33,372 (56%)</td>
</tr>
<tr>
<td>2004/2005</td>
<td>46,000</td>
<td>16,792 (37%)</td>
</tr>
<tr>
<td>2005/2006</td>
<td>50,000</td>
<td>23,595 (47%)</td>
</tr>
<tr>
<td>2006/2007</td>
<td>84,000</td>
<td>58,404 (70%)</td>
</tr>
<tr>
<td>2007/2008</td>
<td>50,000</td>
<td>43,596 (87%)</td>
</tr>
<tr>
<td>2008/2009</td>
<td>80,000</td>
<td>55,114 (69%)</td>
</tr>
<tr>
<td>2009/2010</td>
<td>100,000</td>
<td>69,103 (69%)</td>
</tr>
<tr>
<td>2010/2011</td>
<td>178,000</td>
<td>116,116 (65%)</td>
</tr>
</tbody>
</table>

Average of 37% never made it to farmers as ISP fertilizer

Motivation & objectives

- Diversion further undermines effect of ISPs on total fertilizer demand

- Objectives:
  1. Extend Xu et al. (2009) and Ricker-Gilbert et al. (2011) framework to account for diversion (Mason & Jayne, 2013)
  2. Apply to Malawi, Zambia, Kenya
  3. Benefit-cost analysis (BCA)
Outline

I. Background on ISPs in 3 focus countries
II. Methods & data
III. Results
IV. BCA – status & question for your feedback
V. Conclusions & policy implications

ISPs during period of analysis

• Malawi
  – Targeted; 100 kg fertilizer, 2-4 kg seed
  – Redeem fertilizer coupons at gov’t depots; seed at private retailers

• Zambia
  – Targeted; 400 kg fertilizer, 20 kg seed
  – Distributed through coops

• Kenya
  – National Accelerated Agricultural Inputs Access Programme
    • Targeted; 100 kg fertilizer, 10 kg seed
    • Redeem coupons at private agro-dealers
  – Universal subsidy
    • Kg varies by landholding (roughly)
    • Collect inputs at National Cereals Produce Board depots
Extending Xu et al. (2009) & Ricker-Gilbert et al. (2011) to account for diversion

1. \( total = \text{govt} + \text{comm} \)

2. \[
\frac{\partial \text{total}}{\partial \text{govt}} = \frac{\partial \text{govt}}{\partial \text{govt}} + \frac{\partial \text{comm}}{\partial \text{govt}} = 1 + \frac{\partial \text{comm}}{\partial \text{govt}}
\]

3. \( \text{govt} = \text{nondiverted} + \text{diverted} \)

4. \( \text{allcomm} = \text{comm} + \text{diverted} \)

Previous studies stopped here.
Extending Xu et al. (2009) & Ricker-Gilbert et al. (2011) to account for diversion

(1) \( total = govt + comm \)

(2) \( \frac{\partial total}{\partial govt} = \frac{\partial govt}{\partial govt} + \frac{\partial comm}{\partial govt} = 1 + \frac{\partial comm}{\partial govt} \)  

Previous studies stopped here.

(3) \( govt = nondiverted + diverted \)

(4) \( allcomm = comm + diverted \)

Plug (3) and (4) into (1), take derivative w.r.t. govt, and simplify in terms of things we observe in HH survey data and govt records

(5) \( \frac{\partial total}{\partial govt} = \left[ 1 + \frac{\partial allcomm}{\partial nondiverted} \right] \left[ \frac{\partial nondiverted}{\partial govt} \right] \)

Empirical methods

(5) \( \frac{\partial total}{\partial govt} = \left[ 1 + \frac{\partial allcomm}{\partial nondiverted} \right] \left[ \frac{\partial nondiverted}{\partial govt} \right] \)

Econometrically estimate via:

- HH input demand function for \( allcomm \) with \( nondiverted \) as key covariate, other controls
- Double hurdle model
- Unobserved heterogeneity – HH panel survey data / CRE
- Endogeneity of \( nondiverted \) – CF

Approximate as:

- Total ISP fertilizer rec’d as such by farmers (HH survey data)
- Total ISP fertilizer distributed (gov’t records)
Rural household panel survey data

<table>
<thead>
<tr>
<th>Country</th>
<th>Survey waves</th>
<th>Period</th>
<th>Coverage/representation</th>
<th>N in balanced panel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kenya</td>
<td>5</td>
<td>1997-2010</td>
<td>Nationwide</td>
<td>1,065</td>
</tr>
<tr>
<td>Malawi</td>
<td>3</td>
<td>2002-2009</td>
<td>Nationally-representative</td>
<td>1,375</td>
</tr>
<tr>
<td>Zambia</td>
<td>3</td>
<td>2001-2008</td>
<td>Nationally-representative</td>
<td>4,286</td>
</tr>
</tbody>
</table>

APE of subsidized fertilizer (nondiverted) on HH demand for commercial fertilizer (allcomm)

<table>
<thead>
<tr>
<th>Country</th>
<th>$\Delta_{allcomm}$</th>
<th>$\Delta_{nondiverted}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malawi</td>
<td>-0.18</td>
<td>0.82</td>
</tr>
<tr>
<td>Zambia</td>
<td>-0.13</td>
<td>0.87</td>
</tr>
<tr>
<td>Kenya</td>
<td>-0.43</td>
<td>0.57</td>
</tr>
</tbody>
</table>

Note: p<0.01 for all APEs
APE of subsidized fertilizer \((nondiverted)\) on HH demand for commercial fertilizer \((allcomm)\)

<table>
<thead>
<tr>
<th>Country</th>
<th>(\frac{\Delta allcomm}{\Delta nondiverted})</th>
<th>(\frac{\Delta total}{\Delta govt}) if ignore diversion</th>
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<td>Malawi</td>
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Note: \(p<0.01\) for all APEs

Estimates of diversion rates

- **Zambia**
  - Nationally-rep. HH survey data: mean 37%, median 34%
- **Malawi**
  - Nationally-rep. HH survey data: 25%-45%
  - Holden and Lunduka (2012): up to 33%
- **Kenya**
  - HH survey data not nationally-representative
  - Anecdotal evidence
  - Sensitivity analysis
APE of subsidized fertilizer \((govt)\) on total fertilizer demand \((total)\) accounting for diversion

<table>
<thead>
<tr>
<th>Country</th>
<th>(\frac{\Delta allcomm}{\Delta nondiverted})</th>
<th>(\frac{\Delta total}{\Delta govt} \text{ if ignore diversion})</th>
<th>(\frac{\Delta total}{\Delta govt} \text{ given diversion rate of:})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malawi</td>
<td>-0.18</td>
<td>0.82</td>
<td>0.69 0.55 0.49</td>
</tr>
<tr>
<td>Zambia</td>
<td>-0.13</td>
<td>0.87</td>
<td>0.72 0.58 0.52</td>
</tr>
<tr>
<td>Kenya</td>
<td>-0.43</td>
<td>0.57</td>
<td>0.48 0.38 0.34</td>
</tr>
</tbody>
</table>

Benefit-Cost Analysis

- Computed for 5 years / country
- Currently revisiting
- How to handle diverted fertilizer: should income to a small group of corrupt individuals be considered a “benefit”?
Conclusions

1. Accounting for crowding out and diversion can seriously affect estimates of how ISPs affect total fertilizer demand (& maize production)

2. At diversion rate of 33%, 1 MT of ISP fertilizer increases total demand for fertilizer by:
   - 0.55 MT in Malawi
   - 0.58 MT in Zambia
   - 0.38 MT in Kenya

3. (Not shown) Crowding out effect is lower:
   a. In areas w/ low demand for commercial fertilizer
   b. Among HHs w/ smaller landholdings

Policy Implications

1. Need program innovations to reduce crowding out
   - Target areas where commercial demand not already high
   - Target individual farmers that lack effective demand (landholding or area cultivated as proxy)
   - Greater involvement of the private sector (supply side)

2. Need mechanisms to reduce diversion
   - Better monitoring/auditing of ISP fertilizer; could e-vouchers help?
   - Avoid parallel government distribution system
Thank you

Please see the November 2013 special issue of Agricultural Economics on “Input Subsidy Programs in sub-Saharan Africa” for this article and many others

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