The role of maize price risk in technology adoption: Lessons for policies to promote smallholder productivity

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• Introduction
• Modeling framework
• Modeling downside price risk
• Data and data sources
• Results
• Conclusions and implications for policy
Introduction

• Low productivity and productivity growth
  – continue to be of concern in our maize sectors
  – Due to low fertilizer and seed adoption rates

• In addition to low adoption
  – Some evidence suggests that farmers switch back and forth from adoption and back to disadoption!
  – This is *transient use* of improved technologies

• Few studies have addressed this issue of transience of technology adoption:
Due to preponderance of cross-sectional data:
- lagged behavior is unobserved
- yet this is crucial for tracking technology adoption

What role for output price risk in this?
Major objectives

• Develop a dynamic theoretical model capable of explaining transient use
• Apply the framework to a national panel data set from Kenya
• Using microeconometric techniques, empirically test for the importance of downside price risks
Kenya presents a good case study:

- large maize sub-sector
- input use is relatively high in some agro-eco-zones (by SSA averages)
- political concern that sustainable intensification may be compromised by maize price instability
- these concerns give rise to policy responses (NCPB support prices, import tariffs, etc) with uncertain economy-wide effects
Sequential decision modeling framework

<table>
<thead>
<tr>
<th>Decision 1</th>
<th>Decision 2</th>
<th>Decision 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed choice</td>
<td>Fertilizer use</td>
<td>Fert demand (How much)</td>
</tr>
<tr>
<td>Hybrid</td>
<td>Fert</td>
<td>No Fert</td>
</tr>
<tr>
<td>Non-hybrid</td>
<td>Fert</td>
<td>No Fert</td>
</tr>
</tbody>
</table>
Modeling downside price risk

Risk = \text{Prob}\left(\frac{\text{Expected output price}}{\text{Break - even price (unit cost)}}<1\right)

\begin{align*}
\text{Expected output price} &= f\left(\text{Past prices; Farm & farmer characteristics}\right) \\
\text{Break - even price (unit cost)} &= \frac{\text{Total Variable Costs (Kshs/ha)}}{\text{Estimated yield (g/ha)}}
\end{align*}
Data and data sources

• Balanced panel data from nationally representative surveys
  — Consistent maize growing households

• Focus Group Discussions
## Results: Transient Adoption

<table>
<thead>
<tr>
<th></th>
<th>Percent of Households Using:</th>
<th>Fertilizer</th>
<th>Hybrid Seed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>LP Zone</td>
<td>MP Zone</td>
</tr>
<tr>
<td>One Round</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.8</td>
<td>9.9</td>
</tr>
<tr>
<td>Two Rounds</td>
<td></td>
<td>6.9</td>
<td>8.9</td>
</tr>
<tr>
<td>Three Rounds</td>
<td></td>
<td>15.9</td>
<td>11.1</td>
</tr>
<tr>
<td>Four Rounds</td>
<td></td>
<td>50.3</td>
<td>50.0</td>
</tr>
<tr>
<td>Non-user all 4 rounds</td>
<td></td>
<td>22.1</td>
<td>20.1</td>
</tr>
</tbody>
</table>
Results: Transient Input Use: Comparing fertilizer use (kg/acre) btw the four waves

- 2000 vs 1997
- 2004 vs 2000
- 2007 vs 2004
**Results:** Distribution of fertilizer rates (kg/acre) 1997-2007

- **Low Potential (LP) Zone**
  - Kernel density estimate
  - Fertilizer application rate (kg/acre)
  - Density
  - Kernel = epanechnikov, bandwidth = 2.4451

- **Medium Potential (MP) Zone**
  - Kernel density estimate
  - Fertilizer application rate (kg/acre)
  - Density
  - Kernel = epanechnikov, bandwidth = 2.6958

- **High Potential (HP) Zone**
  - Kernel density estimate
  - Fertilizer application rate (kg/acre)
  - Density
  - Kernel = epanechnikov, bandwidth = 3.7513
## Results: Estimated Impacts of Risk and Prices on hybrid and fertilizer use

<table>
<thead>
<tr>
<th></th>
<th>Coef.</th>
<th>Std. Err.</th>
<th>Significance</th>
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</thead>
<tbody>
<tr>
<td><strong>Decision to use Hybrid</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk Variable</td>
<td>-0.085</td>
<td>0.134</td>
<td>None</td>
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<tr>
<td>Predicted Maize Price</td>
<td>0.369</td>
<td>0.136</td>
<td>0.100</td>
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<tr>
<td>Fertilizer Price</td>
<td>-0.005</td>
<td>0.006</td>
<td>None</td>
</tr>
<tr>
<td><strong>Decision to adopt fertilizer</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Risk Variable</td>
<td>-0.592</td>
<td>0.052</td>
<td>0.050</td>
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<tr>
<td>Predicted Maize Price</td>
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<td>None</td>
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<tr>
<td>Fertilizer Price</td>
<td>-0.027</td>
<td>0.007</td>
<td>0.050</td>
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<tr>
<td><strong>Fertilizer application rate</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk Variable</td>
<td>-0.022</td>
<td>1.040</td>
<td>None</td>
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<tr>
<td>Predicted Maize Price</td>
<td>0.510</td>
<td>0.216</td>
<td>0.100</td>
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<tr>
<td>Fertilizer Price</td>
<td>-0.133</td>
<td>0.045</td>
<td>0.001</td>
</tr>
</tbody>
</table>
Results: Distribution of Breakeven Prices

Estimated at data average: 14kg/acre

Estimated at: 100kg/acre
Results: Observed Prices compared to Breakeven Price at 100kg/acre

Observed maize prices: Kshs/kg

Estimated breakeven maize prices: Kshs/kg
**Results:** Comparing Breakeven Price (at 100kg/acre) and Predicted Price

Cumulative Distribution of Breakeven Revenue and Predicted Maize Prices

- **Predicted Price (A)** (Kshs/kg)
- **Breakeven Price (B)** (Kshs/kg)
- **A minus B**
- **B minus P**

# Graph

![Graph showing cumulative distribution of Breakeven Revenue and Predicted Maize Prices](image_url)
Policy Implications

• Low input use in subsistence modes comes at a steep cost: in terms of unexploited economic opportunities
  – achievable from higher input use

• Low fertilizer dosages are unprofitable (esp. for those who can ill afford it)

• Granted: in the semi-arid (LP) areas, low fertilizer use reflects low and variable response rates to fertilizer application
Policy Implications

• In the majority of cases (esp MP and HP zones):
  — raising application rates from low to medium levels reduces maize production costs
  — hence using more fertilizer (up to a point):
    • will increase the probability to break-even

• This suggests one reason why downside maize price risk has small effect on the demand for fertilizer
  — As can be seen from previous econometric results
Conclusions

• Capital constraints (fertilizer price) rather than overwhelming concern with downside price risk
  – may constrain sustained technology adoption

• Once investments to lower the costs or improve efficiency of fertilizers are made:
  – The importance of downside maize price risk will recede even further, i.e.
  – maize production could be more profitable at increased levels of fertilizer

• We argue this (increased input use) should be predicated on expanding the reach of grain markets