Background

- Farm productivity growth:
  - Precondition for economic development in most of the developing world
  - Achieving this productivity growth is likely to involve substantially increased use of fertilizer
Background

- Current fertilizer use in sub-Saharan Africa: 9 kg/ha
  - Lowest of any developing region

- African policy makers recognize the urgency of raising fertilizer use by small farmers
  - But little consensus on the most appropriate policy

Motivation

- Relatively little emphasis on improving profitability of fertilizer use through understanding the most productive levels for various:
  - Agro-ecological areas
  - Management practices
  - Market conditions

- Zambia has one nationally-recommended application rate (200kgs of Compound D and 200kgs of urea/ha of maize)
Objectives

- Estimate maize yield response to fertilizers under a range of small farm conditions and management practices
- Determine profitability of fertilizer use for various soils, climates, management practices, and market conditions
- Identify the potential to increase fertilizer use and profitability through public policy tools

Challenges

- Measurement error
  - Inputs
- Data aggregation
  - Multiple plot problem
- Latent variable
  - Lagged phosphorous application unknown
Challenges

- Collinearity between nitrogen and phosphorus
  - Farmers tend to follow the extension service recommendation in terms of N/P proportion
  - Impossible to reliably estimate their individual effects

- Measurement of soils and climates
  - Requires categorizing estimates of soil types, soil pH and climate (rainfall) into meaningful sized groups

Approach

- In simple cases theory suggests the properties of parameter estimates; for more complex situations Monte Carlo simulation is used to provide insights into those properties
- Use robust estimation techniques
Theoretical Framework

- Crop yields can be seen as a function of input variables and exogenous variables
  \[ y = f(x_i, Z), i=1,\ldots,n. \]
  - \( y \) is stochastic yield
  - \( x_i \) is \( i \)th input variable
    - Fertilizer, seed, labor, etc.
  - \( Z \) is vector of exogenous variables beyond farmer's control
    - Soil, weather, etc.

- Yield response function and input-output price ratio together determine profit maximizing level of input use

Data & Methods

  - nationally representative annual survey
  - covers roughly 7500 rural households each year

- Other data utilized:
  - Agro-climatic zone
  - Soil type
  - Soil ph
  - Household characteristics

- Nitrogen index is used to capture the “package” effect of \( N \) and \( P \) because of collinearity; some regressions are restricted to the predominant \( N \) to \( P \) ratios
Yield Response Model

Household-level variables considered include
- Age of household head (HH)
- Gender of HH (1=female, 0=male)
- Use of either mechanical or animal draft power (1=yes, 0=no)
- Nitrogen (kg/ha)
- Whether fertilizer was available on time (1=yes, 0=no)
- Whether used hybrid seed (1=yes, 0=no)
- Whether seed was available on time (1=yes, 0=no)
- Hectares of maize cultivated

Results

Plots of yields v.s. $N$ and the corresponding lowess smoothing curves suggest that response is linear up to the level of approximately 110kg/ha for each category of households

<table>
<thead>
<tr>
<th>Household category</th>
<th>Used mechanical or animal draft power</th>
<th>Fertilizer was available on time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Group 2</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Group 3</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Group 4</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Controlling for location, estimate of marginal product of $N$ is lowest for Group 1 and highest for Group 4
Results

- Value-cost ratio (VCR) is highest for Group 4 (used mechanical or animal draft power and fertilizer was available on time) and lowest for Group 1 (did not use power and fertilizer was not available on time).

- For the same category of households, VCR is lower in remote districts than their corresponding provincial centers.

Results

- Applying fertilizer is more likely to be profitable for households:
  - living near provincial centers
  - obtained fertilizer on time
  - used animal draft or mechanical power

- Greater distances and transport costs from provincial centers erode the profitability of fertilizer use.

- If interest rate is high, fertilizer use may not be profitable.
Economic analyses of fertilization suggest three key messages:

- First, households that obtained fertilizer on time used animal draft or mechanical power are more likely to find fertilizer use profitable than other groups of households located in the same area.

- Second, farmers’ proximity to provincial centers has a significant impact on the profitability of fertilizer use.

- Third, high interest rate also reduce profitability of fertilizer use.

Implications

- Reduce transportation costs through investment in infrastructure
- Find ways to reduce interest rates
  - Need more effective system of loan recovery
- Ensure more timely delivery of fertilizer
  - Government programs provide subsidized fertilizer but if they deliver to farmers late, this offsets the effect of the subsidy on farmers’ ability to profitably use fertilizer
Thank you