MAIZE YIELD RESPONSE TO FERTILIZER AND PROFITABILITY OF FERTILIZER USE AMONG SMALL-SCALE MAIZE PRODUCERS IN ZAMBIA

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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

    Figure 1
  - 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 *ith* 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

- Maize production data: 1996/97-1999/2000, Central Statistical Office
  - 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

Household category	Used mechanical or animal draft power	Fertilizer was available on time
Group 1	No	No
Group 2	Yes	No
Group 3	No	Yes
Group 4	Yes	Yes

- 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:

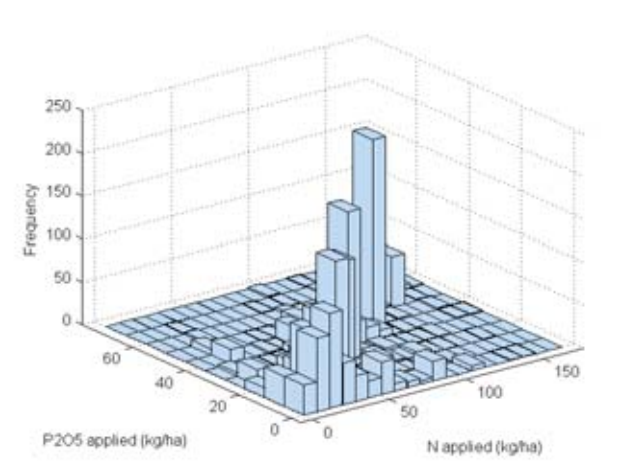
- First, households that
  - obtained fertilizer on time
  - used animal draft or mechanical power

  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



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