Technical Efficiency and Adoption of Conservation Practices in Iowa Soybean Production

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Motivation
- Challenges faced by the soybean industry in Iowa
  - Stagnant yield, see Figure 1
  - Rising cost of production partly driven by costs of land and machinery
  - Higher cost of production than country average, see Figure 2
  - Infrastructure improvements in South America erode competitive advantage of Iowa soybeans in transportation costs to international markets.
  - Environmental impact: soil erosion and non-point source pollution of corn and soybean rotations in the Midwest contribute to the hypoxia of the Northern Gulf of Mexico

Background on Production Efficiency
- Economic efficiency: technical efficiency and allocative efficiency
- Measure technical efficiency: comparison of the observed and the optimal values of input and output
- Competing approaches to measure technical efficiency:
  - Econometrics approach: Stochastic Frontier Analysis (SFA) tries to distinguish the effects of inefficiency from that of noise, providing basis for statistical inference
  - Programming approach: Data Envelopment Analysis (DEA) is non-parametric and avoids confounding effects from misspecification of the functional form
- We choose DEA over SFA
  - Nature of the problem: we cannot observe the true potential, thus associate the "efficiency" with "best practices". DEA envelopes the data to identify the set of best practices
  - To take advantage of the non-parametric approach, with bootstrapping technique to conduct statistical inference

Banker, Charnes and Cooper (1984)

Performance Indicators of Iowa Soybean Farms
- USDA defines soybean farms as those with soybeans or related commodities making up at least 50 percent of their total value of production
- Breakdown of performance indicators: profitbility and productivity
- No data on soybean farmers’ adoption of conservation practices available.

Table 1: Performance Indicators of Iowa Soybean Farms

<table>
<thead>
<tr>
<th>Type of Indicator</th>
<th>Values</th>
<th>Changes</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profitability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value of Farm Production per Unit of Input</td>
<td>$11.98</td>
<td>$3.27</td>
<td>29%</td>
</tr>
<tr>
<td>Productivity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soybean Yield per Acre Planted</td>
<td>4.6</td>
<td>5.5</td>
<td>14%</td>
</tr>
<tr>
<td>Productivity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forking Rate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current Asset Basis Rate</td>
<td>81.5%</td>
<td>81.56%</td>
<td>2%</td>
</tr>
<tr>
<td>Productivity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soybean Yield per Acre Planted</td>
<td>3.3</td>
<td>4.6</td>
<td>33%</td>
</tr>
<tr>
<td>Productivity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acres Operated per Farm</td>
<td>129</td>
<td>133</td>
<td>2%</td>
</tr>
</tbody>
</table>

Our Objective
- Provide farm specific efficiency measures and identify the drivers of technical efficiency.
- Characterize the pattern of adoption of conservation practices according to levels of technical efficiency.

Methodology
- Stage one: "envelope" the data to identify the best practices frontier, by expanding output while controlling for input

\[ ES^k (\lambda^k, x^k) = \max \lambda \]

subject to

\[ \lambda y^k \leq z^k \]

\[ x^k \geq X_{z^k} \]

\[ z^k \in \mathbb{R}^k \]

- Linear programming → farm specific efficiency measure \( \lambda_f \) which measures the distance between the farm and the efficiency frontier. Farms on the efficiency frontier receive a score of 1.
- Stage two: Regress farm efficiency scores \( \lambda_f \) on farm characteristics, production and marketing practices, soil and weather data, and demographic information
- Stage three: Correlate adoption of conservation practices with private costs, cost-share payments, and farm efficiency scores \( \lambda_f \)

Data
- Stage one: data collected by surveys sent to over 5,000 soybean farmers in Iowa:
  - Farm size, production, income, costs
  - Financial management
  - Adoption of conservation practices, private costs, cost-share programs
  - Demographic information
- Stage two: county level data from various sources:
  - Soil data from STATSGO
  - Weather data from PRISM
  - Price, corn-soy ratio from USDA
  - Rural-urban continuum code from ERS

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