Alternative Green Payment Policies under Heterogeneity when Multiple Benefits Matter

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Background

- Conservation Security Program (CSP) proposes paying farmers for the adoption of environmentally friendly practices

- Approach: **green payments for practices**, with possible targeting of benefits or practice

- Environmentally-friendly agricultural practices generate multiple benefits, but value of these benefits uncertain
Problem facing policy maker

- Maximize environmental benefits from green payment program

  Social utility:  \( U = U(X_1, \ldots, X_K) \)

  where  \( X_1 = \sum X_1^n = \text{total amount of benefit 1, etc.} \)

  \( c^n = \text{cost of enrolling farm } n \text{ (bids)} \)

  \( C = \text{budget} \)

- Which bids should be accepted?
How to choose farms to enroll?

- Define \( x_k^n = X_k^n/c^n \) = environmental attribute k received per dollar spent on farm n

- Total environmental contribution per dollar spent from each farm
  \[ v^n = U_1 x_1^n + U_2 x_2^n + \ldots + U_K x_K^n \]

- Rank order \( v^n \) highest to lowest, enroll farms until exhaust budget

- Target practice: rank order \( 1/c^n \) highest to lowest, enroll farms until exhaust budget

- Target single benefit j: rank order \( x_j^n \) highest to lowest, enroll farms until exhaust budget
Targeting single benefit

- How to summarize the environmental benefits of a particular targeting program?

- How do we compare alternative targeting schemes? What is the best/optimal targeting scheme?
Our paper

• Develop a methodology of summarizing multiple benefits from targeting
  • Lorenz curve: targeting one benefit, the percentage of other benefits generated relative to their respective maxima (under direct targeting)
  • Depends on the correlation of the rank order of the benefits/

• Use Lorenz curves to choose optimal targeting
  • Special utility functions: with perfect or no substitutability among benefits

• Empirically apply the methodology to conservation tillage in Iowa
Previous research

- **CRP**

- **CSP**
  - Johansson, Claassen, and Peters 2002
  - Baylis et al 2002
Lorenz curves

- \( w(C, i, j) = \) ratio between benefit \( i \) obtained when targeting \( j \) and that obtained when targeting \( i \), under budget \( C \)

- Higher curves indicate better choice of targeting

- Curves are higher as
  - The fields are more homogeneous
  - Rank order of benefits/$ is more positively correlated
  - The budget rises
Choosing optimal targeting

- Special utility functions:

\[ U(X_1, \ldots, X_K) = \sum_{k=1}^{K} \alpha_k X_k \]

\[ U(X_1, \ldots, X_K) = \min\{\alpha_k X_k, k = 1, \ldots, K\} \]

- Under perfect substitutability, vertical summation of Lorenz curves, i.e. target attribute that gives the highest percentage of total achievable benefits

- Under Leontieff, max-min of Lorenz curves, i.e. target attribute that assures the greatest level of the minimum attribute
Equal weight vs. max-min criterion

- Preferred by equal weight
- Preferred by max-min

Benefits

N_RUNOFF targeted

CARBON targeted

Budget, $1,000,000
Conservation tillage in Iowa

- Econometric model of adoption of conservation till
- EPIC for environmental indicators
  - Carbon
  - Nitrogen runoff
  - Water Erosion
  - Wind Erosion
- Model and EPIC runs predict at NRI level (13,000 points)
## Benefits of a practice targeting policy

<table>
<thead>
<tr>
<th>Budget</th>
<th>10 Mil $</th>
<th>20 Mil $</th>
<th>40 Mil $</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon, 1,000 tons</td>
<td>169</td>
<td>296</td>
<td>495</td>
</tr>
<tr>
<td>N Runoff reduction, tons</td>
<td>237</td>
<td>406</td>
<td>671</td>
</tr>
<tr>
<td>Water erosion reduction, 1,000 tons</td>
<td>597</td>
<td>1033</td>
<td>1729</td>
</tr>
<tr>
<td>Wind erosion reduction, tons</td>
<td>704</td>
<td>1206</td>
<td>1976</td>
</tr>
</tbody>
</table>
Lorenz curves:
Benefits obtainable under a practice-vs. specific benefit-targeting policy
Lorenz curves: Benefits obtainable under a wind-erosion-vs. specific benefit - targeting policy

- Carbon
- Nitrogen runoff
- Water erosion
Lorenz curves: Benefits obtainable under a N-runoff-vs. specific benefit - targeting policy

- Carbon
- Water erosion
- Wind erosion

Budget, Mil $

Proportions of benefits

0 20 40 60 80 100

Budget, Mil $

Proportions of benefits
### Best targeting strategies under different criteria

<table>
<thead>
<tr>
<th>Budget, Mil $</th>
<th>Equal weight</th>
<th>Max min</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-36</td>
<td>Minimize Nitrogen runoff</td>
<td>Minimize Nitrogen runoff</td>
</tr>
<tr>
<td>38-70</td>
<td>Minimize Nitrogen runoff</td>
<td>Maximize carbon sequestration</td>
</tr>
<tr>
<td>72-80</td>
<td>Maximize carbon sequestration</td>
<td>Maximize carbon sequestration</td>
</tr>
</tbody>
</table>
Future directions

- More environmental indicators
- Spatial aspects: SWAT
- Beyond Iowa: UMRB
- Institutions