Types of Decisions

- Where should the biorefinery be located?
- What is the optimal spatial and temporal mix of feedstocks?
- What is the optimal configuration of the biomass supply chain?
- How to structure biomass supply contracts?
- How to ensure participation of small/minority/tribal farmers?
- How would the land use in the region evolve over time due to presence of the biorefinery and what are the implications for the biorefinery?

Decision Support Systems for Regional Planning and Impact Assessment of Biorefineries*

A. Survey research aimed at assessing the acceptability of biorefineries to communities
B. A biomass harvest-shed design tool to help determine the optimal mix
C. A logistics decision support tool to help evaluate alternative feedstock supply chain configurations.
D. Feasibility of RBPC in Eastern Upper Peninsula of Michigan
E. Contract design research
F. Dynamic agent based simulation modeling tool to help predict the evolution of the harvest shed over time, under alternative market development scenarios

* USDA-NIFA Grant 2012-67009-19693
BIOREFINERY ACCEPTABILITY

- Survey of 1,000 Michigan Households
- Explored:
  - Willingness to accept biorefinery
  - Reasons to accept/reject biorefinery

- 65% supported having a new biorefinery in their community; 27% were opposed and 8% were undecided

Predicted Probability of Support

Dark Red: >90%, Dark Blue: <60%

Key Reasons to Support / Oppose Biorefinery

<table>
<thead>
<tr>
<th>Support (N=640)</th>
<th>Biggest Advantage (%)</th>
<th>Smallest Advantage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Job Creation</td>
<td>45.15</td>
<td>8.3</td>
</tr>
<tr>
<td>Increased Sales for Area Farmers</td>
<td>11.06</td>
<td>18.7</td>
</tr>
<tr>
<td>Environmental Benefits</td>
<td>10.40</td>
<td>17.3</td>
</tr>
<tr>
<td>The Plant Would Pay Local Taxes</td>
<td>8.14</td>
<td>27.1</td>
</tr>
<tr>
<td>Reducing Dependence on Foreign Oil</td>
<td>22.37</td>
<td>38.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Oppose (N=353)</th>
<th>Biggest Drawback (%)</th>
<th>Smallest Drawback (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily Smells or Noises</td>
<td>7.37</td>
<td>15.01</td>
</tr>
<tr>
<td>Long-term Environmental Effects</td>
<td>26.35</td>
<td>6.23</td>
</tr>
<tr>
<td>More Traffic on the Road</td>
<td>5.1</td>
<td>28.9</td>
</tr>
<tr>
<td>Risk of Industrial Accidents</td>
<td>2.83</td>
<td>11.05</td>
</tr>
<tr>
<td>Biofuels not Economically Viable</td>
<td>33.14</td>
<td>9.92</td>
</tr>
<tr>
<td>Biofuels Increase Food Prices</td>
<td>13.31</td>
<td>12.46</td>
</tr>
</tbody>
</table>
HARVEST-SHED DESIGN TOOL

- Math Programming model to determine the optimal mix of annual crops and perennial grasses for a generic biorefinery, taking into account the necessary contract terms, feedstock costs, transport costs, GHG emissions, and other environmental impacts.

RESULTS

- Objective: minimize the discounted total biomass procurement costs (material, harvesting, transport, storage, external costs)

SPATIAL AND TEMPORAL DISTRIBUTION

- Distribution matrix showing distribution across years and areas.
Key Insights
- Energy crops will likely account for a significant proportion of the optimal feedstock mix, despite higher establishment costs and the need for long-term contracts.
- Higher yields/acre and associated lower transport costs offset the higher costs of feedstock production.
- Agricultural residues are likely to be used primarily to cover shortfalls in energy crops.
- Spatially, energy crops will be contracted closer to the biorefinery, while agricultural residues will likely be collected from the fringe areas.

ALTERNATIVE SUPPLY CHAIN CONFIGURATIONS
- **Single Integrated Biorefinery**
  - Intermediate processing with alternative product (animal feed) can address market power, ‘chicken and egg’, food v/s fuel issues
- **Distributed Configuration with RBPCs**
  - Distributed system will have longer average transport distance and double handling costs, but intermediate densification can offset costs

Feasibility of Regional Preprocessing
- Assessing land availability, potential biomass supply and cost
- Estimating capital and operating costs of RBP, appropriate scale of operations and production costs
- Local demand for animal feed and feed cost competitiveness
- Overall financial feasibility
RBPC COST ESTIMATES

<table>
<thead>
<tr>
<th>RBPC Capacity Tons/Day</th>
<th>25</th>
<th>50</th>
<th>100</th>
<th>200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Capital costs 000</td>
<td>$3,685</td>
<td>$5,756</td>
<td>$9,344</td>
<td>$15,677</td>
</tr>
<tr>
<td>Total Operating costs /ton</td>
<td>$77.20</td>
<td>$56.75</td>
<td>$43.08</td>
<td>$34.30</td>
</tr>
</tbody>
</table>

CASE-STUDY: Feasibility in Michigan’s Eastern Upper Peninsula

- Total cropland ~ 50-70K acres
- AFEX plant size = 140-200 tpd
- Capital cost = $15.7 M
- Operating cost = $35/ton
- Capital & depreciation costs = $25/ton
- Switchgrass production cost = $70/t
- MSP of animal feed = $155/t
- Not enough animal feed demand

Not a financially attractive project.

Contract Design for Biorefinery Procurement

- OBJECTIVE(S):
  - Access willingness of ag. producers to grow energy crops
  - Estimate preferences for potential contract attributes

- METHODS:
  - Conducted focus groups and follow-up questionnaire of 26 producers in April 2013
Contract Design for Biofeedstock Procurement

**FINDINGS:**
- Producers were somewhat familiar with energy crops
- 87% of producers would commit at least 21% of ag land to energy crops if offered favorable contract
- 86% of producers would commit at least 21% of their time to energy crops if offered favorable contract
- Little correlation between demographic characteristics and commitment

**FINDINGS:**
- Primary factors influencing producers’ decision include:
  - Agronomic attributes (e.g. affect on other crops),
  - Production practices (e.g. need to invest in specific equipment), and
  - Prior existence of supply chain (EX.: Mascoma)
  - Adoption by other community members

**FINDINGS:**
- Preferences for contract terms:
  - Long-term contract to match longevity of crop
  - Upfront payment; quantity and quality should have moderate impact on returns
  - Producers conduct field work
  - Weather risk should be borne by processor or shared (with other producers and/or processor)
  - Willing to store biomass if processor is responsible for transportation
Evolution Model of the Harvest Shed for Michigan Biofeedstock

OBJECTIVE:
- Model availability of biofeedstock harvest shed over time and space and under alternative market development scenarios

METHOD:
- Use simulation techniques to model the decision-making process of multiple stakeholders
- Evaluate farmer adoption of energy crops under various market development scenarios

ALTERNATIVE MARKET SCENARIOS:
1. A biorefinery procures from Individual farmers – no farmer protection
2. A biorefinery procures from farmer cooperative
   - Introducing competition for biorefinery, reducing monopsony power
3. Multiple easily accessible market outlets

STUDY AREA AND DATA:
- 573 Farmers in total, populated by CLU land ownership data and census data
- Alfalfa, Corn, Soybeans, Wheat
- Real and projected crop yield, crop price and crop input cost data (2008 to 2022)
- Crop Budget from MSU Extension and Kell & Swinton (2014)
KEY FINDINGS:

- Farmers are quite unwilling to convert land into switchgrass use as the contract hold up risk is quite high.

- Cooperative procurement is a quite efficient and realistic way to procure switchgrass. When working with cooperative, biorefinery might be willing to coordinate with geographically separated industries to foster alternative outlets with transaction cost.

- Switchgrass yield under 3 scenarios might not be enough to meet commercial-scale biorefineries’ procurement capacity; need technologies that increases yield, or procure in Southern states.
PROJECT OUTPUTS

Publications:

PROJECT OUTPUTS

THESES

- Haoyang Li: “Farmers’ switchgrass adoption decision under different market scenarios— an agent based modeling approach” M.S. Thesis 2014