An empirical application of the output allocation model for major U.S. crops

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Motivation

- How much major crop supplies are affected by output and input prices are important questions for food security concerns.
- Agricultural policies in the U.S. focus on supporting output prices with relatively little attention to input prices.
- However, crop productions seem to react sensitively to input price changes.
- Therefore, linking input and output markets in models of supply response is crucial since farmers’ planting decisions are based on the joint effect from the two markets.

Objective

- Our objective is to develop an empirical output allocation model for the U.S., linking input and output markets in a large system.
- We treat the agricultural crops sector as a multiproduct firm that jointly produces four crops (soybeans, corn, wheat, and cotton) using five inputs (land, labor, fertilizer, pesticides, and energy).

Methodology

- Our empirical output allocation model is

\[ g_{r,s} \cdot DZ_{r,s} = \theta_r^p DZ_r + \sum_{i=1}^{m} \pi_{r,i} dp_{r,i} + \sum_{j=1}^{n} \pi_{r,j} dp_{r,j} + \epsilon_{r,s} \]

where \( g \) is revenue share and \( z \) is the quantity of the \( r \)th product. \( DZ \) is the Divisia output index, \( y \) is the output price, and \( p \) is the input price. The system has \( m \) products and \( n \) inputs.

- Adding-up conditions are \( \sum_{r=1}^{m} g_{r,s} = 1 \), \( \sum_{r=1}^{m} z_{r,s} = 0 \), \( \sum_{r=1}^{m} \pi_{r,s} = 0 \). Homogeneity conditions are \( z_{r,s} \sim z_{r,s} \) for all \( r, s \).

- We recently developed this empirical model by linearizing the theoretical nonlinear model of output allocation developed by Laitinen in 1980.
- Our model does not assume input-output separability or output independence; although these constraints can be imposed.

Data

- Data on input prices, output prices, and output quantities between 1975-2011 were obtained from USDA-ERS.
- All prices and quantities were normalized to be 1 in 2005.
- Producers plant these crops prior to any knowledge of the harvest prices. So, we used last period’s (log changes in) output prices. This also accounts for potential endogeneity bias.
- We use Maximum Likelihood methods to estimate the system.

Results

Table 1. Divisia Elasticities

<table>
<thead>
<tr>
<th>Product</th>
<th>Soybean</th>
<th>Corn</th>
<th>Wheat</th>
<th>Cotton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soybean</td>
<td>0.26***</td>
<td>0.15**</td>
<td>-0.38***</td>
<td>-0.03</td>
</tr>
<tr>
<td>Corn</td>
<td>0.37***</td>
<td>-0.32**</td>
<td>-0.17**</td>
<td>-0.15</td>
</tr>
<tr>
<td>Wheat</td>
<td>0.03</td>
<td>0.03**</td>
<td>-0.41</td>
<td>-0.09</td>
</tr>
<tr>
<td>Cotton</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Divisia elasticity shows supply responsiveness of a particular crop to a 1% increase in the “average” crop supply. Wheat supply seems to react faster than that of other crops.

Table 2. Output Price Elasticities

<table>
<thead>
<tr>
<th>Product</th>
<th>Soybean</th>
<th>Corn</th>
<th>Wheat</th>
<th>Cotton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soybean</td>
<td>0.50***</td>
<td>0.08</td>
<td>-0.47***</td>
<td>-0.20</td>
</tr>
<tr>
<td>Corn</td>
<td>0.63***</td>
<td>0.12</td>
<td>-0.56***</td>
<td>-0.43***</td>
</tr>
<tr>
<td>Wheat</td>
<td>-0.11***</td>
<td>-0.02</td>
<td>0.12**</td>
<td>0.06**</td>
</tr>
<tr>
<td>Cotton</td>
<td>0.24</td>
<td>0.08</td>
<td>-0.41</td>
<td>-0.09</td>
</tr>
</tbody>
</table>

- Prices of all inputs, except for the fertilizer, have significant impacts on the output allocation decision among the four crops. Corn and soybean supply are more sensitive to input price changes than wheat and cotton supply.

Conclusion

- Corn and soybean supply respond to both output and input price changes. Government programs through both output and input prices would be effective in changing the production of corn and soybeans in the U.S.
- Wheat and cotton do not respond as much to input or output prices. Government’s wheat and cotton programs may have been playing stronger role than the market forces in affecting their acreages.

Contact Information

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