Innovation, Climate, and Ontario Corn

and Soybean Yield

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Innovation, Climate, and Ontario Corn and Soybean Yield

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Corn and soybean have been two major agricultural commodities in Ontario.

How innovation effects crop yield distributions?

Innovation does not necessarily shift the yield distribution upwards uniformly. Often innovation moves mass from one part of the distribution to another part. Moreover, the effects of technological changes could be different under changing climate. We use the Normal Distribution Mixture model to capture possibly different rates of technological change.

Figure 1: Ontario estimated crop area tilled and cash receipts in 2015. Source: Statistics, Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA).

Model I: Yield & climate

\[ y_{i,t} = f(\text{Grow.length}_{i,t}, \text{Trend}, \text{Climate variables}_{i,t}) \]  

where \( i \) denotes county and \( t = \{1, \ldots, T\} \).

Conceptual framework

The following two models investigate yield-climate relationship. Equation (1) and (3) are estimated using least squares with county fixed effects. Equation (2) is estimated using Expectation-Maximization algorithm.

Figure 2: Essex county corn and soybean yield from 1950 to 2013. The blue line is the estimated mean of the “good” year yield realization. The “bad” years are in pink. The black line is the observed yield. Figure 3: Changing thresholds. The three vertical lines denote the precipitation thresholds for the different periods of time. After reaching these thresholds (i.e., plants get enough water for growing), the yield per acre rises slowly. Notice that the precipitation thresholds increases through time.

Table 1: Estimation results: yield-climate relationship.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Yield</th>
<th>Soybean</th>
<th>Corn</th>
<th>Soybean</th>
<th>Corn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trend</td>
<td>0.313**</td>
<td>1.333***</td>
<td>0.015**</td>
<td>0.014***</td>
<td></td>
</tr>
<tr>
<td>Prec.JA</td>
<td>1.913***</td>
<td>4.358***</td>
<td>-0.054***</td>
<td>-0.077***</td>
<td></td>
</tr>
<tr>
<td>VPD.JA</td>
<td>0.728**</td>
<td>0.707</td>
<td>0.433</td>
<td>0.228**</td>
<td></td>
</tr>
<tr>
<td>p-value</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td></td>
</tr>
</tbody>
</table>

Note: *p<0.1; **p<0.05; ***p<0.01

Marginal effects

Table 2: Marginal effects for interaction terms.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Soybean</th>
<th>Corn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield</td>
<td>Soybean</td>
<td>Corn</td>
</tr>
<tr>
<td>Yield</td>
<td>0.014**</td>
<td>0.004**</td>
</tr>
<tr>
<td>p-value</td>
<td>(0.010)</td>
<td>(0.008)</td>
</tr>
</tbody>
</table>

Findings

1. Rates of technological change differ in the “good” and “bad” years. The rate of technological change tends to be higher in the upper component than it is in the lower one.
2. The probability of “bad” harvest is statistically increasing over time.
3. Yields are becoming more susceptible to precipitation shortfalls over time.

Implications of findings

1. Different rates of technological change and increasing probability of lower yield realization jointly may put a financial burden on Business Risk Management programs.
2. Producers do not appear to be adopting risk-reducing technologies but rather using subsidized crop insurance to take care of the lower tail; this is optimal in many cases.
3. Co-insurance may create more incentives for producers to adopt more risk reducing technologies.

Forthcoming Research

Our analysis will be extended to consider innovation and climate effects on yield volatilities for both upper and lower tails of the yield distribution. Potential findings would be important to Ontario Business Risk Management programs and crop insurance policies.

Normal mixture models are continuously estimated using the Expectation-Maximization algorithm.