A Structural Model of US Corn Farmers’ Pest Control Decisions:
Rootworm Resistance in US Corn Fields

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A Structural Model of U.S. Corn Farmers’ Pest Control Decisions: Rootworm Resistance in U.S. Corn Fields

Seth Wechsler • USDA, Economic Research Service

INTRODUCTION

Marine-derived genetically engineered, rootworm-resistant (Bt-CRW) seeds in 2005. Unfortunately, it appears that rootworms may be adapting to the toxins produced by these seeds.

• 2006: Unexpectedly high yield losses were first reported in Illinois and Indiana.
• 2011: Reports of unexpectedly high yield losses spread to NE, IA, and SD.
• 2012: Entomologists published a public letter suggesting that EPA act with “a sense of urgency” to prevent resistance from developing.
• 2015: The EPA proposes a limited timeframe for development of rootworm-resistant management.

RESEARCH QUESTIONS

1. How does Bt-CRW adoption affect pest control decision-making?
2. How have benefits associated with Bt-CRW adoption changed over time? Can these changes be attributed to the development of rootworm-resistant management?

Average unexpected yield losses from rootworms (on untreated acres)

<table>
<thead>
<tr>
<th>Year</th>
<th>2005</th>
<th>2010</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bt-CRW Use</td>
<td>26.8%</td>
<td>9.2%</td>
<td>17.5%</td>
</tr>
</tbody>
</table>

THE TIMING OF CORN FARMERS’ INSECTICIDE USE DECISIONS

FORMULATING A DAMAGE ABATEMENT MODEL OF PEST CONTROL DECISIONS

damage abatement models account for the fact that pesticides are used in a band only when pest pressure is above a certain threshold.

SOLVING THE STRUCTURAL MODEL

The theoretical model itself is solved in two stages:

Stage 1: Deriving a Demand Function for Topical Insecticides

Step 1: Estimating Control Functions for Bt-CRW adoption.

Step 2: Deriving a Demand Function for Topical Insecticides

R = βY + ε

Stage 2: Estimating an Extreme Value Distributed, Left-Censored, Soil Insecticide Demand Function

where Y represents potential yields, and ε represents the vector of factors affecting the severity of rootworm damage.

ESTIMATING SOIL INSECTICIDE DEMAND

A two-stage, control function-based approach is used to account for the endogeneity of soil insecticide use and expected yields.

Step 1: Estimating Control Functions for Bt-CRW Adoption/Expected Yields

A random effects probit model is used to analyze farmers’ Bt-CRW adoption decisions. A restricted, linear-form specification is used to analyze expected yields.

Step 2: Estimating an Extreme Value Distributed, Left-Censored, Soil Insecticide Demand Function

A restricted, linear-form specification is estimated:

where V represents potential yields, and ε represents the vector of factors affecting the severity of rootworm damage.

REGRESSION RESULTS

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>t-Value</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bt-CRW Use</td>
<td>0.12*</td>
<td>0.06</td>
<td>2.00</td>
<td>0.045</td>
</tr>
<tr>
<td>Winter Temperature</td>
<td>-0.01</td>
<td>0.005</td>
<td>-2.00</td>
<td>0.045</td>
</tr>
<tr>
<td>Deviation from Average February Precipitation</td>
<td>0.02</td>
<td>0.01</td>
<td>2.00</td>
<td>0.045</td>
</tr>
<tr>
<td>Deviation from Average Winter Temperature</td>
<td>0.01</td>
<td>0.005</td>
<td>2.00</td>
<td>0.045</td>
</tr>
<tr>
<td>Deviation from Average February Precipitation</td>
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</tr>
</tbody>
</table>

IMPACTS OF BT-CRW ADOPTION

On average, using rootworm-resistant seeds decreased soil insecticide use by approximately 60% to 80% across the sample. These decreases were driven by a reduction in the probability of using soil insecticides in late storms or at rotation.

Benefits of Adoption Tend To Be More Pronounced for Bt-CRW Adaptors

CONCLUSIONS

Rootworm resistance was widespread in 2010. Future work will analyze data that is being collected in 2015, 2016, 2017, and 2018.

Bt-CRW use reduced insecticide use from 2005 to 2010. For instance, farmers using Bt-CRW seeds would have applied 70% fewer insecticide treatments to their fields in 2010 compared to 2005.

Bt-CRW adoption increased U.S. corn yields over the course of the study period. The magnitude of the effect varied with the severity of the infestation.

Source: (ARMS Phase II Corn Surveys 2005 and 2010)