A STRUCTURAL ESTIMATION OF THE DEMAND FOR CORN SEED IN THE US
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RESEARCH QUESTION
Genetically Modified (GM) seed has been rapidly adopted in recent years, but the social welfare effect of this new technology is still unclear for us. Motivated by clear economic meaning, structural approach allows for behavior model test and social welfare effect assessment. The purpose of this paper is to use the newly developed structural estimation models and techniques to estimate farmers’ demand for GM seed and to evaluate the social welfare of introduction of new seed technology.

BACKGROUND
Fast GM Corn Seed Adoption:

BLP MODEL
BLP model assumes heterogeneous consumers, i.e., farmers have different reactions to each trait of the same type. Thus
\[ \beta_i = \beta + \Pi_i + \Sigma_i, \quad \nu_i \sim N(0,1) \]
where \( D_i \) is a vector of demographic variables of farmer \( i \), \( \nu_i \) is a vector of her unobserved tastes for each product characteristics. Then
\[ \pi_{ij} = x_j\beta - \alpha p_j + \xi_j + \Pi_i x_j + \Sigma_i x_j + \epsilon_{ij}, \]
Let \( \delta_j = x_j \beta - \alpha p_j + \xi_j - \epsilon_0 \) defined as the mean profit derived from seed \( j \) and \( \mu_{ij} = \Pi_i x_j + \Sigma_i x_j \) defined as the farmer’s specific heterogeneous taste for attributes in seed \( j \), then
\[ \pi_{ij} = \delta_j + \mu_{ij} + \epsilon_{ij}, \quad (4) \]
Similar as in the Logit model, the probability of farmer i choosing seed j, \( P_{ij} \), is
\[ P_{ij} = \frac{e^{\delta_j + \mu_{ij}}}{1 + \sum_{l=1}^{J} e^{\delta_l + \mu_{lj}}} \]
Suppose \( \nu \) and \( D \) follow some distribution \( F(\nu, D) \), then the market share can be obtained by integrated \( P_{ij} \) over all \( \nu_i \) and \( D_i \),
\[ s_j = \int P_{ij} dF(\nu, D). \quad (5) \]
BLP provided a contraction mapping to get the mean profit vector \( \delta \):
\[ T(\delta) = \delta + \ln(s^*) - \ln(s) \quad (6) \]
Recall that
\[ \delta_j = x_j \beta - \alpha p_j + \xi_j - \epsilon_0 \quad \text{for } j = 1, 2, \ldots, J. \quad (7) \]
Suppose \( Z \) is a set of instrument variables which are independent of \( \xi \). Let \( g = Z' \xi \), then we can estimate the parameters in (7) by minimizing the GMM objective function
\[ \min g' W g \]
where \( W \) is a \( M \times M \) weigh matrix.

LOGIT MODEL
Suppose for \( j^{th} \) type of corn hybrid, \( x_j \) is a vector of characteristics and \( \xi_j \) is the unobserved characteristics. With price \( p_j \), the profit for farmer i to grow seed j is
\[ \pi_{ij} = x_j\beta - \alpha p_j + \xi_j, \quad (1) \]
where \( \epsilon_{ij} \) is an i.i.d. error with extreme value distribution. Normalize the price of the outside option as zero, and let \( \delta_j = x_j \beta - \alpha p_j + \xi_j - \epsilon_0 \), then
\[ \pi_{ij} = \delta_j + \epsilon_{ij} \quad \text{for } j = 0, 1, 2, \ldots, J. \quad (2) \]
According to the Logit model, the probability that the farmer will choose \( j^{th} \) type of corn seed is
\[ s_j = \frac{e^{\delta_j}}{1 + \sum_{l=1}^{J} e^{\delta_l}} \quad \text{and} \quad s_0 = \frac{1}{1 + \sum_{l=1}^{J} e^{\delta_l}} \]
which is virtually the market share of seed j. Follow the standard approach we can derive
\[ \log s_j - \log s_0 = \beta x_j - \alpha (p_j - p_0) + (\xi_j - \xi_0). \quad (3) \]
Assuming the unobserved attribute \( \xi \) is independent with prices and observed characteristics, we can estimate \( \beta \) and \( \alpha \) in Equation (3) using ordinary least square (OLS) estimation.

DATA AND RESULT
Data:
We use the data from an extensive survey on U.S. corn farmers in 2007. It provides information including farmers’ purchasing records like prices, discounts, quantities, acreage, etc, and information about the seed itself, like seed variety, embedded biotech traits, brand, etc. This survey also provides a projection factor to aggregate the farmer level information to market level statistics. There are a total of 25,588 purchase records with 5,714 surveyed farmers from 34 U.S. states in our data set. The market is defined as the state level.

Result:

<table>
<thead>
<tr>
<th>variables</th>
<th>logit</th>
<th>logit IV</th>
<th>BLP without IV</th>
<th>BLP IV</th>
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<tbody>
<tr>
<td></td>
<td>coeff</td>
<td>se</td>
<td>coeff</td>
<td>se</td>
</tr>
<tr>
<td>Constant</td>
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<td>0.051</td>
<td>-3.464</td>
<td>0.747</td>
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<tr>
<td>Bt</td>
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<td>0.066</td>
<td>1.475</td>
<td>0.355</td>
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<tr>
<td>RW</td>
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<td>0.084</td>
<td>1.542</td>
<td>0.381</td>
</tr>
<tr>
<td>HT</td>
<td>-0.269</td>
<td>0.053</td>
<td>1.440</td>
<td>0.351</td>
</tr>
<tr>
<td>BtRWHT</td>
<td>0.493</td>
<td>0.085</td>
<td>-0.271</td>
<td>0.194</td>
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<tr>
<td>price</td>
<td>0.583</td>
<td>0.107</td>
<td>-0.678</td>
<td>0.283</td>
</tr>
</tbody>
</table>

Instrument Variables:
Instrument variables are the brand of traits embedded in the seed. Because the Seed company has to pay license fee in order to get the right to use the trait, and the brands of those traits are proxies of the quality, therefore the brand of traits contain the cost information of those traits. From the preliminary results in the above tables we can see that after introducing the instrument variable, the coefficient for price changed from positive to negative in the logit case and increased in multitude in the BLP model. All the other coefficients are also consistent with our expectation.

SOCIAL WELFARE IMPLICATION: TO DO
The characteristics of the hybrids include insect resistance which can kill the European Corn Borer (ECB) or root worms (RW), and herbicide tolerance (HT) which is designed to reduce weeds. A typical GM corn seed may contain one or more traits from the same bio-tech company or different bio-tech companies. The following table shows the stacking of corn seed. Among the stacked seed, BtHT and BtRWHT are the dominant stacking seeds, so we take these two stacking system as additional characteristics in the following estimation.

<table>
<thead>
<tr>
<th></th>
<th>Conv</th>
<th>Single Bt</th>
<th>Single RW</th>
<th>Single HT</th>
<th>BtRW</th>
<th>BtHT</th>
<th>BtRWHT</th>
<th>total</th>
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<tbody>
<tr>
<td></td>
<td>2820</td>
<td>1064</td>
<td>94</td>
<td>2559</td>
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<td>382</td>
<td>2240</td>
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