An Empirical Structural Model of Productivity and the Conservation Reserve Program Participation

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An Empirical Structural Model of Productivity and the Conservation Reserve Program Participation

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Introduction

Through annual rental payment and long-term contract, the Conservation Reserve Program (CRP) provides financial incentives for landowners to idle environmentally sensitive farmland. In 2011, CRP paid $17 billion to idle about 31 million acres, which is roughly equivalent to the size of total farmland in Iowa. In the last few years, however, CRP has faced a number of significant challenges. Record-high commodity crop prices had a significant impact on the CRP enrollment. Figure 1 shows that CRP land went down by 10 million acres between 2007 and 2012, which account for 27% of total enrolled acres in 2007. Following the changes in market conditions, the 2014 Farm Bill allows participants to terminate the contract prior to its expiration without penalty. The 2014 Farm Bill also reduces the cap of CRP acres by 8 million acres. Despite an extensive literature on CRP, we lack evidence on how landowners react to changes in agricultural market conditions and CRP payment rates and how the factors affect the program enrollment and cost.

Findings

• A 10% increase in farm productivity leads to a CRP payment premium of $4.9-$8.02 per acre.

• Impact on CRP would be significant if agricultural prices remain high and landowners can flexibly withdraw the CRP contracts.

• Increasing CRP payment can offset effects of high agricultural prices to some extent, but it will significantly increase the program cost.

Model

The profit function associated with the optimal land allocations is written as

\[ \Pi(p, r, \omega, L) = \max L \left( \sum_{i=1}^{h} p_i - \sum_{i=1}^{h} r_i - \sum_{i=1}^{h} \omega_i L_i = L \right) \] (1)

The optimal output supply and acreage allocations are obtained from the first-order conditions of the profit function.

We specify the Normalized Quadratic profit function and consider three land uses: (i) crop production, (ii) land in CRP, and (iii) remaining other land uses. For farmer \( k \) in state \( s \) at time \( t \), the output supply and two land use equations are specified as

\[ Q_{kt} = \alpha_1 + \alpha_2 p_{kt} + \alpha_3 r_{kt} + \alpha_4 L_{kt} + \alpha_5 \omega_{kt} + \varepsilon_{kt} \] (2)

\[ L_{kt} = \theta_1 + \theta_2 p_{kt} + \theta_3 r_{kt} + \theta_4 L_{kt} + \theta_5 \omega_{kt} + \varepsilon_{kt} \] (3)

\[ L_{kt} = \theta_1 + \theta_2 p_{kt} + \theta_3 r_{kt} + \theta_4 L_{kt} + \theta_5 \omega_{kt} + \varepsilon_{kt} \] (4)

where \( p_{kt} \) and \( r_{kt} \) are composite output and input prices in state \( s \), \( L_{kt} \) is the CRP payment. \( L_{kt} \) is the total land. \( \omega_{kt} \) is the unsolded productivity. \( \varepsilon_{kt} \) and \( \varepsilon_{kt} \) are the error terms.

To deal with the endogeneity, the CRP payment function is specified as

\[ \delta_{kt} = b(\omega_{kt}, m_{kt}, L_{kt}, \lambda_k) \] (5)

where \( m_{kt} \) is the county market rental rate. \( \lambda_k \) collects the farm-level demographic variables.

Use the inverse to proxy for the productivity, i.e.,

\[ b^{-1}(\omega_{kt}, m_{kt}, L_{kt}, \lambda_k) \equiv \omega_{kt} \] (6)

Model (cont’d)

• Define an indicator function to deal with landowners’ self-selection:

\[ B_{kt} = \begin{cases} 1 & \text{if } B_{kt} \geq \frac{\beta_0}{\beta_1}(m_{kt}, L_{kt}, \omega_{kt}, \lambda_k) \\ 0 & \text{otherwise} \end{cases} \] (6)

where \( \omega_{kt} \) is a vector of the county agro-climatic conditions.

Identification of the coefficients comes from the dynamics of the productivity that follows the first-order Markov process:

\[ \omega_{kt} = \mathbf{E}(\omega_{kt+1} | \omega_{kt}, B_{kt} = 1) = \mathbf{E}(\omega_{kt+1} | \omega_{kt}, B_{kt} = 0) \] (7)

where \( \lambda_k \) is the inverse mill ratio (IMR) from the probit regression.

Empirical Results

Table 1: Decision on CRP Participation

<table>
<thead>
<tr>
<th>Land rental price</th>
<th>Marginal effect</th>
<th>Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0.0005/acre</td>
<td>-0.096 (0.00004)</td>
<td>-0.43 (0.00002)</td>
</tr>
<tr>
<td>Total land in farm</td>
<td>0.0005/acre</td>
<td>0.05 (0.00002)</td>
</tr>
<tr>
<td>Operator’s age</td>
<td>0.004 (0.00011)</td>
<td>0.46 (0.00017)</td>
</tr>
<tr>
<td>Days worked off farm</td>
<td>0.01 (0.00045)</td>
<td>0.18 (0.00047)</td>
</tr>
<tr>
<td># Observations</td>
<td>38,071</td>
<td>38,071</td>
</tr>
</tbody>
</table>

Table 2: Output Supply and Land Allocations

<table>
<thead>
<tr>
<th>County</th>
<th>Output supply</th>
<th>Crop</th>
<th>CRP</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>County 1</td>
<td>100,000</td>
<td>50,000</td>
<td>40,000</td>
<td>10,000</td>
</tr>
<tr>
<td>County 2</td>
<td>150,000</td>
<td>70,000</td>
<td>50,000</td>
<td>30,000</td>
</tr>
</tbody>
</table>

Table 3: Payment Premium of Higher Productivity Farms

<table>
<thead>
<tr>
<th>Farm</th>
<th>Payment Premium</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm A</td>
<td>4.90</td>
<td>Iowa</td>
</tr>
<tr>
<td>Farm B</td>
<td>8.02</td>
<td>Iowa</td>
</tr>
</tbody>
</table>

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