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

Heesun Jang
Ph.D. Candidate
Dept. of Ag & Applied Economics
University of Wisconsin-Madison
hjang28@wisc.edu

Xiaodong Du
Assistant Professor
Dept. of Ag & Applied Economics
University of Wisconsin-Madison
xdu23@wisc.edu

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Heesun Jang and Xiaodong Du

Agricultural and Applied Economics, University of Wisconsin-Madison

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 $1.7 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.

Objectives

To what extent do agricultural market conditions and CRP rental rates affect landowners' CRP enrollment?

- Incorporate landowners' CRP decisions in profit maximizing land allocation model and explicitly account for
  - Endogeneity of CRP payment and self-selection of landowners into CRP.
  - Linkage between landowner's bid and agricultural productivity.
- Analyze CRP payment premium of productive landowners.
- Simulate the land use changes at alternative agricultural prices and CRP payment across the Corn Belt states.

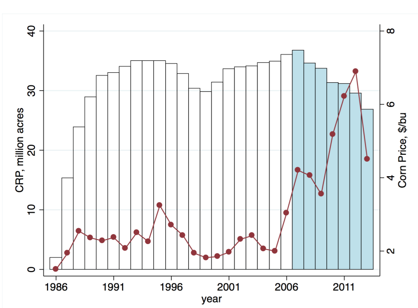

Figure 1: CRP Acreage and Corn Price, 1986-2013

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

$$\Pi(\mathbf{p},\mathbf{r},\omega,L)=\max_{l_1,\ldots,l_h}\Pi\left(\mathbf{p},\mathbf{r},\omega,l_1,\ldots l_h \mid \sum_{i=1}^{h} l_i = L\right) \quad (1)$$

- 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 l^a, (ii) land in CRP l^c, and (iii) remaining other land uses l^m.
- For farmer k in state s at time t, the output supply and two land use equations are specified as

$$Q_{kt}=\alpha_1+\alpha_{11}p_{st}+\alpha_{12}r_{st}+\alpha_{13}b_{kt}+\gamma_1 L_{kt}+\delta_1\omega_{kt}+\upsilon_{kt} \quad (2)$$

$$l^a_{kt}=\theta_1+\theta_{11}p_{st}+\theta_{12}r_{st}+\theta_{13}b_{kt}+\theta_{14}L_{kt}+\theta_{15}\omega_{kt}+\upsilon^a_{kt} \quad (3)$$

$$l^c_{kt}=\theta_2+\theta_{21}p_{st}+\theta_{22}r_{st}+\theta_{23}b_{kt}+\theta_{24}L_{kt}+\theta_{25}\omega_{kt}+\upsilon^c_{kt} \quad (4)$$

where p_{st} and r_{st} are composite output and input prices in state s. b_{kt} is the CRP payment. L_{kt} is the total land. ω_{kt} is the unobserved productivity. υ_{kt}, υ^a_{kt}, υ^c_{kt} are the error terms.

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

$$b_{kt}=b\left(\omega_{kt},m_{ct},L_{kt},\mathbf{z}_{kt}\right) \quad (5)$$

where m_{ct} is the county market rental rate. $\mathbf{z}_{kt}$ collects the farm-level demographic variables.

- Use the inverse to proxy for the productivity, i.e., $b^{-1}(\omega_{kt},m_{ct},L_{kt},\mathbf{z}_{kt})\equiv\omega(b_{kt},m_{ct},L_{kt},\mathbf{z}_{kt})$.

Model (cont'd)

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

$$B_{kt}=\begin{cases}1 \text{ if } B^*_{kt}\geq \underline{B}^*_{kt}\left(m_{ct},L_{kt},\mathbf{z}_{kt},\mathbf{c}_{ct}\right)\\ 0 \text{ otherwise}\end{cases} \quad (6)$$

where $\mathbf{c}_{ct}$ 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:

$$\begin{aligned}\omega_{kt}&=\mathbb{E}\left(\omega_{kt}\mid\omega_{kt-1},B_{kt}=1\right)+\varepsilon_{kt}\\&=g\left(b_{kt-1},m_{ct-1},L_{kt-1},\mathbf{z}_{kt-1},\lambda_{kt}\right)+\varepsilon_{kt}\end{aligned} \quad (7)$$

where λ_{kt} is the inverse mills ratio (IMR) from the probit regression.

Empirical Results

	Marginal effect	Elasticity
Land rental price	-0.001 (0.00004)[c]	-0.19 (0.006)[c]
Total land in farm	0.00005 (0.000002)[c]	0.05 (0.002)[c]
Operator's age	0.004 (0.0001)[c]	0.46 (0.01)[c]
Days worked off farm		
2	0.02 (0.005)[c]	
3	0.01 (0.008)[b]	
4	0.01 (0.006)[c]	
5	0.01 (0.004)[c]	
Soil index	0.13 (0.005)[c]	0.55 (0.02)[c]
Growing degree days	-0.0001 (0.000007)[c]	-0.36 (0.02)[c]
# Observations	89,732	89,732

Table 1: Decision on CRP Participation

	Output supply	Cropland	CRP land
Constant	-8844.48 (6154.18)	-26.94 (62.93)	70.61 (30.53)[b]
Output price	6791.86 (486.54)[c]	31.44 (5.20)[c]	-13.89 (2.49)[c]
Fertilizer price	-203.55 (16.30)[c]	-0.95 (0.17)[c]	0.42 (0.08)[c]
CRP payment	-497.63 (149.97)[c]	-7.01 (1.64)[c]	3.06 (0.83)[c]
Total land in farm	10.21 (0.88)[c]	0.72 (0.01)[c]	0.01 (0.004)[c]
# Observations	18,328	18,328	18,328

Table 2: Output Supply and Land Allocations

	Dependent variable: CRP payment							
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)
Productivity estimates	0.55 (0.004)[c]	0.76 (0.008)[c]	0.79 (0.01)[c]	0.83 (0.01)[c]	0.90 (0.01)[c]	0.75 (0.008)[c]	0.77 (0.009)[c]	0.76 (0.009)[c]
Land rental price		0.06 (0.004)[c]	0.12 (0.01)[c]	0.42 (0.02)[c]	1.80 (0.01)[c]	0.10 (0.005)[c]	0.15 (0.005)[c]	0.16 (0.005)[c]
Total land in farm		-0.18 (0.002)[c]	-0.23 (0.005)[c]	-0.25 (0.004)[c]	-0.34 (0.004)[c]	-0.17 (0.003)[c]	-0.18 (0.003)[c]	-0.18 (0.003)[c]
Operator's age		1.30 (0.007)[c]	0.89 (0.02)[c]	0.81 (0.01)[c]	0.28 (0.008)[c]	1.27 (0.007)[c]	1.25 (0.008)[c]	1.22 (0.008)[c]
Days worked off farm		0.23 (0.003)[c]	0.16 (0.004)[c]	0.15 (0.003)[c]	0.06 (0.002)[c]	0.22 (0.003)[c]	0.22 (0.003)[c]	0.22 (0.003)[c]
Fixed effect								
County			X	X				
State						X	X	
Time				X			X	
County-time					X			
State-time								X
R-squared	0.41	0.99	0.99	0.99	0.99	0.99	0.99	0.99
# Observations	38,071	38,071	38,071	38,071	38,071	38,071	38,071	38,071

Table 3: Payment Premium of Higher Productivity Farms

Policy Simulation

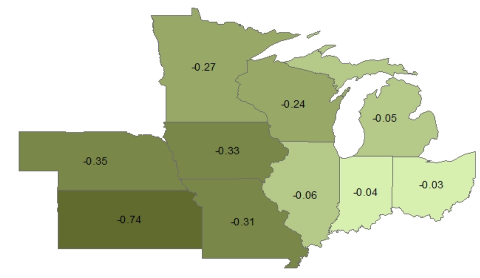

Figure 2: Actual Changes in CRP Acreage, 2007-2012

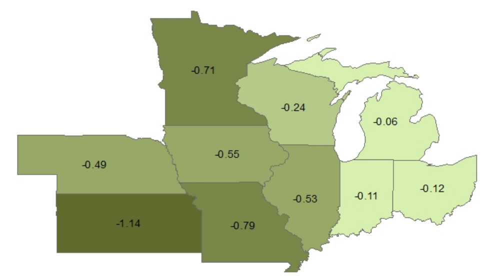

Figure 3: Predicted Changes in CRP Acreage, 2007-2012

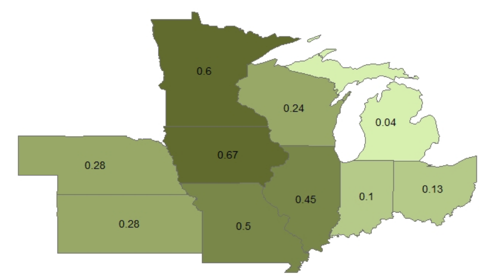

Figure 4: Additional CRP Acreage by 10% Increase in 2012 CRP Payment

Contact Information

- Email: hjang28@wisc.edu
- Phone: +1 (608) 886 7361