Input price risk and the adoption of conservation technology

Karina Schoengold[1] and David L. Sunding[2]

1. Department of Agricultural Economics, School of Natural Resources, University of Nebraska – Lincoln

2. Department of Agricultural and Resource Economics, University of California-Berkeley

Introduction

Technological innovation can lead to the development of new technologies that use natural resources more efficiently. When a new technology is available, consumers need to decide if they will adopt it. One factor that affects this decision is input price risk. With energy, this uncertainty has been exacerbated in recent years by price trends with increasing mean and variance.

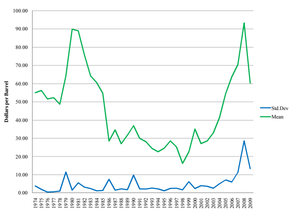

Figure 1. Mean and Standard Deviation of Monthly Oil Prices (1974-2009) Source: EIA

Key research question: *Are producers more likely to adopt conservation when input prices are stochastic?*

Economic Model

We consider a profit maximizing producer who has access to two production technologies. The model is based on previous work by Caswell and Zilberman (1986).

A producer has access to a conservation technology (i=1) and a conventional technology (i=0).
Thus, $\alpha_1 > \alpha_0$.

Definition	Parameter
Input-use efficiency	α
Input price	w
Input quantity	x
Output quantity	Y
Production function	h(αx)
Fixed capital cost	κ

Technology Choice

Constant Input Prices:

$$\max_i h_i(\alpha_i x_i^*) - \overline{w} x_i^* - \kappa_i$$

Stochastic Input Prices:

Let $\tilde{w}_i(h_i(.), \alpha_i)$ = break even input price for technology i

Since $\alpha_1 > \alpha_0 \Rightarrow \tilde{w}_1 \geq \tilde{w}_0$

Price distribution : $w \sim f(w) \in [w_L, w_H]$

Mean water price : $E[w] = \overline{w}$

Choosing a technology under stochastic input prices:

$$\max_i \int_{w_L}^{\tilde{w}_i} [h(\alpha_i x_i^*(w)) - w x_i^*(w)] f(w) dw - \kappa_i$$

Economic Model: Key Results:

Proposition 1: *All else equal, shutdown rates will be at least as high under stochastic input prices*

Proposition 2: *Under stochastic input prices, shutdown rates are higher under conventional technology than under conservation technology*

Data used for analysis:
(see Schoengold et al., 2006 for additional information)

•Arvin Edison Water and Soil District (near Bakersfield, California)
•Years: 1997-2002

Field level data:
•Crop
•Irrigation technology
•Field size
•Elevation
•Soil permeability
•Frost-free days
•Surface/groundwater

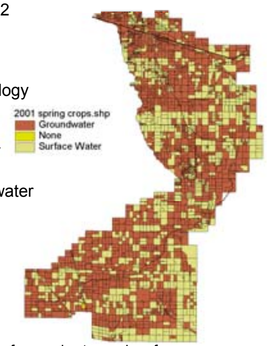

Figure 2. Distribution of groundwater and surface water

Econometric Model and Results

Key variables:
Surface water or groundwater:
•Each field has a single source of water
•Surface water users pay a fixed fee per acre-foot
•Groundwater cost depends on energy prices
Irrigation technology:
•Drip or microsprinkler – high water use efficiency
•Sprinkler – medium water use efficiency
•Gravity – low water use efficiency
For estimation purposes:
•Conventional = Gravity irrigation
•Conservation = Sprinkler, drip, or microsprinkler

Verification of Economic Model

Variable	All Fields Marginal Effect		All Fields Std. Error	Surface Water Marginal Effect		Surface Water Std. Error	Groundwater Marginal Effect		Groundwater Std. Error
Surface water	-0.0681	***	0.016	-		-	-		-
Conservation irrigation	-0.13	***	0.0268	-0.0802	*	0.0433	-0.152	***	0.0342
Spring crop = truck crop	0.108	***	0.016	0.145	***	0.0262	0.0858	***	0.0204
No. of Observations	4604			1923			2681		

Table 1: Probit estimation of fall fallowing decisions.

Results (consistent with predicted responses):
•Producers with fixed input price are *less* likely to fallow a field
•For producers with stochastic input prices, those with conservation irrigation are *less* likely to fallow a field

Variable	Coefficient		Std. Error
Surface water	164.5		172
Field size	-8.81		11.2
Spring crop = truck crop	-0.684	***	0.0694
Elevation	4.05	***	0.525
Soil permeability	1.04	***	0.222
Frost-free days	-0.218	*	0.129
WSA x Size of field	17.2		18.8
WSA x Elevation	-0.383		0.655
WSA x Soil permeability	-0.196		0.375
WSA x Frost-free days	-0.597		0.626
Number of Observations	4596		
Pseudo R2	0.2327		

Table 2: Probit estimation of the adoption of conservation technology adoption (Fixed effects by year and township included). A joint test of all WSA coefficients shows insignificance.

Problems with Probit: underlying differences in the treated and control groups

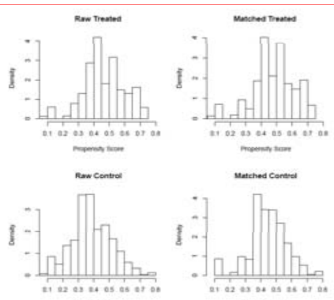

Figure 3. Estimated propensity scores for treated (surface water) and control (groundwater)

Matching results: the *average treatment effect* (ATE) based on propensity score matching is *insignificant*

Alternative Estimation:

Pre-processing (Ho et al., 2007):
Step 1: Process the data and keep only observations that are matched.
Step 2: Proceed with standard parametric estimation:

Variable	Total Marginal Effect		Std. Error
Surface water	0.0287	***	0.00086
Field size	-0.227		1.69
Spring crop = truck crop	-0.785	***	0.013
Elevation	0.38	***	0.061
Soil permeability	0.102	***	0.0332
Frost-free days	-0.305		0.290
Interaction terms	Marginal Effect		Std. Error
WSA x Size of field	-2.11		2.37
WSA x Elevation	-0.2812	***	0.0798
WSA x Soil permeability	-0.728		0.438
WSA x Frost-free days	-0.572		0.579

Table 3: Probit estimation of the adoption of conservation technology adoption (Fixed effects by year and township included)

Results and Implications:
•After correcting for sample differences, producers with a fixed input price are more likely to adopt conservation
•Correcting for differences in sample characteristics is important in determining the effect of price risk
•Results could have implications for determining technology choices based on fixed price contracts or by source of input

Literature cited

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For further information:

Please contact *kschoengold2@unl.edu*