

# Input price risk and the adoption of conservation technology

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## 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.

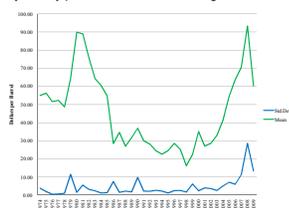


Figure 1. Mean and Standard Deviation of Monthly Oil Prices (1974-2009) Source: EIA

**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).

Definition	Parameter
A producer has access to a conservation technology ( $i=1$ ) and a conventional technology ( $i=0$ ). Thus, $\alpha_1 > \alpha_0$ .	
Input-use efficiency	$\alpha$
Input price	$w$
Input quantity	$X$
Output quantity	$Y$
Production function	$h(\alpha X)$
Fixed capital cost	$K$

## Technology Choice

### Constant Input Prices:

$$\text{Max}_i h_i(\alpha_i, x_i^*) - \bar{w}x_i^* - \kappa_i$$

### Stochastic Input Prices:

Let  $\tilde{w}_i(h_i(\cdot), \alpha_i)$  = 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 :  $E[w] = \bar{w}$

Choosing a technology under stochastic input prices:

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

## 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

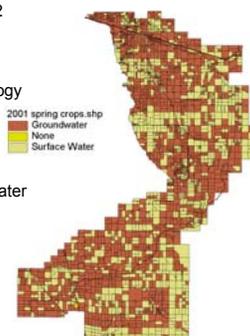


Figure 2. Distribution of groundwater and surface water

## 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		Surface Water		Groundwater	
	Marginal Effect	Std. Error	Marginal Effect	Std. Error	Marginal Effect	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 follow a field
- For producers with stochastic input prices, those with conservation irrigation are less likely to follow 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

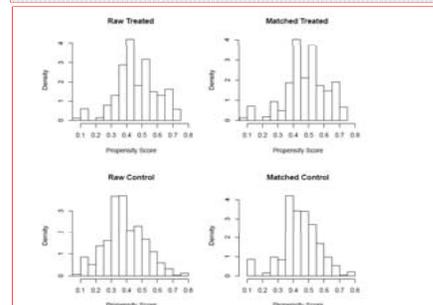


Figure 3. Estimated propensity scores for treated (surface water) and control (groundwater)

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		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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Ho, D. E., Imai, K., King, G. & Stuart, E. A. (2007), 'Matching as nonparametric preprocessing for reducing model dependence in parametric causal inference', *Political Analysis* 15: 199-236.

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