Input Price Uncertainty, the Rebound Effect and Conservation Technology Adoption

Georgina Moreno and David Sunding

Department of Agricultural and Resource Economics
207 Giannini Hall
University of California at Berkeley
Berkeley, CA 94703
email: gmoreno@are.berkeley.edu
(510) 642-3345
(510) 643-8911 (fax)

DRAFT

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1 Introduction

In recent years, growing concern for the environment has placed increasing emphasis on resource conservation. Attention on conservation has been recently focused on energy use and global warming (Jaffe and Stavins 1994). This concept, however can be extended to other environmental concerns. For example, a reduction in water use for irrigation can reduce diversions from water ways but also reduce polluted run-off (EPA 1995). Hausman (1979) was one of the first papers to address the issue of conservation technology adoption. Hausman investigates consumer behavior with respect to choice of air-conditioners. He models consumer behavior in a two-stage model, where the consumer makes two decisions: initial capital choice and utilization. The empirical analysis finds that consumers indeed balance fixed costs with operating costs. Furthermore, he estimates consumer's discount rates to be quite high relative to "engineering calculations" His analysis suggests that successful conservation policy should consider the complex relationship between individual characteristics and the capital-utilization trade-off associated with adopting conservation technology.

This paper addresses how price volatility affects conservation technology adoption given the capital-utilization trade-off discussed by Hausman. The usual assumption is that risk does not have much impact in adoption – this has been argued going back to Griliches, but has certainly been argued more recently by others like Mundlak. Just and Zilberman (1983) have asserted the contrary by considering, theoretically at least, the influence of risk aversion on technology adoption. We show theoretically, and most importantly, empirically that price risk does have a large influence on technology adoption even if individuals are risk-neutral. This point is also made in the option value literature, for example Hasset and Metcalf (1995) and Pindyck (1991).

Our research complements the option value approach and gives a fuller picture of the impact of price uncertainty on technology adoption. However, our work differs from the option value literature in several ways. First, we focus on the choice of technology rather the timing of the investment. In our model the agent chooses the level of conservation by choosing the technology's input-output coefficient. Second, we find that price risk affects the choice of resource-using technology even without irreversibility.

Using Hausman's framework, we develop a general model of the effect of input price uncertainty on conservation technology adoption. We derive comparative static results to predict the conservation response to input price uncertainty. We present the conceptual model in a general form, applicable to a variety of conservation scenarios. For example, the consumer's decision to adopt high-efficiency automobiles or a farmer's choice of irrigation technology. We test the model empirically using field-level irrigation technology data from California's San Joaquin Valley.

One feature of our model is to make the rebound effect of conservation technology adoption explicit. Environmental benefits from adoption of conservation technology assume that adoption reduces demand for natural resources. The rebound effect, which is an increase in utilization of the technology from decreased operating cost, may significantly reduce the resource savings from adoption of conservation technology (Greene, Kahn and Gibson 1999). The benefits of conservation from the technology adoption may be overstated if the rebound effect is ignored (Wirl 2000). By endogenizing the utilization level into the technology adoption decision, our model incorporates the rebound effect. Volatility of input prices (e.g.

electricity, gasoline, natural gas, water) help explain the slow rate of adoption of conservation technology if the rebound effect is in a certain range.

This paper is organized into 4 sections. In Section 2, we develop a model that distinguishes between long-term investments in conservation technology and short-term decisions about the level of utilization. We show that the relationship between input price volatility and technology adoption is complex. We identify realistic cases in which increasing price risk can increase or decrease the incentive to adopt conservation technology. One of our main conceptual results is that the responsiveness of utilization to changes in the input price has an important impact on investment behavior. For example, we show that the impact of a mean-preserving decrease in the variance of input price on conservation technology choice depends on the elasticity of utilization with respect to the input price. One implication of this and other findings is that changes in the distribution of input price have different effects on different types of economic activities.

In Section 3 we present our empirical analysis. Here we test the model using field-level data and our results strongly support our model. The empirical model predicts an increased incentive for conservation technology adoption when input price risk increases for a production activity that is relatively unresponsive to input price (i.e., permanent crop production) but a decreased incentive to adopt conservation technology for a production activity that is relative responsive to input price (i.e., annual crop production). In Section 4 we conclude and discuss the policy implications of our findings.

2 Model

Conservation technology is technology that has the lowest input requirement per unit of output, relative to the alternative technologies. The technology is characterized as putty-clay in terms of input use intensity: The input-output ratio is fixed in the short-run, but malleable in the long-run. (Johansen 1959, Atkeson and Kehoe 1999) In the long-run, technologies can be substituted with different types of technologies. For example, resource-intensive technologies can be substituted with resource-conserving technologies. Since we are interested in individual behavior with respect to conservation, we model the decision at the microunit, that is, the individual production unit. This can be a consumer choosing an automobile or home appliance, a firm choosing a machine for a particular process, or a farmer choosing irrigation technology for a field.

Following Hausman (1979), the agent makes a two-stage decision. In the short-run, the agent chooses the level of utilization, for example, miles driven, degree-hours cooled, or acres in production. In the long-run, the agent chooses conservation by choosing the input-output coefficient, a of the technology. Given the broad range of conservation practices available, from investing in new equipment to changing habits, we model the technology choice as a continuum of technologies measured by the choice of input-output coefficient.

The agent faces a stochastic input price, p, assumed to be the constant marginal cost of the input (i.e., gasoline, electricity, water, etc.). The probability distribution of the input price can be affected by climatic conditions as well as by policy. While the policy maker may not be able affect when resource shocks occur, she can affect the probability distribution of resource supply through various policies. These may include policies in response to the shocks, investment in infrastructure, and policies to protect the environment. Here we focus on the policy maker's impact on the probability distribution of input price. We assume that p has a known distribution $F(p;\theta)$, where θ is the policy parameter which reflects how policy affects the price volatility. The support of $F(p;\theta)$ is $[\underline{p},\bar{p}]$ and we assume p is *IID*.

2.1 Short-run Equilibrium: The Utilization Decision

In the short-run, efficiency of the technology is fixed and input price is known. The agent chooses utilization, x, to maximize short-run welfare. Short-run welfare is defined as short-run benefits from utilization less operating costs given a fixed input-output coefficient, $\bar{a}$. The agent's short-run optimization problem is given by

$$\max_{x} W^{SR} = B(x) - p\bar{a}x - z(\bar{a}), \tag{1}$$

where $B(x)$ are benefits from production of services. We assume that $B(x)$ is concave in x. The function $z(\bar{a})$ the annualized cost of technology adoption, as a function of the input-output coefficient. A higher input-output coefficient implies a lower level of conservation, and technologies with lower input-output coefficients (higher conservation) require larger investments. Thus, expediture on technology is decreasing in a, that is, $z'(\bar{a}) < 0$.

The first order condition for the agent's short-run problem is

$$B'(x) - p\bar{a} = 0, \tag{2}$$

which implicitly defines the optimal level of x as a function of p and $\bar{z}$,

$$x^* = x(p, \bar{a}). \tag{3}$$

From the optimality condition in (2), we obtain the comparative statics

$$\frac{dx}{d\bar{a}} = \frac{p}{SOC_{SR}} < 0 \tag{4}$$

and

$$\frac{dx}{dp} = \frac{\bar{a}}{SOC_{SR}} < 0, \tag{5}$$

where $SOC_{SR} = B''(x) < 0$, the short-run second order condition for an interior maximum. Equation (4) reflects the rebound effect, which implies that utilization changes in the opposite direction to the input-output ratio, or in terms of conservation, utilization increases with conservation. Equation (5) is negative, as expected for an input demand.

Using the optimality condition in (2), define the shut-down input price, $\hat{p}$, as

$$\hat{p}(a) = \{p | B(x) - p\bar{a}x^* - z(\bar{}) = 0\}. \tag{6}$$

At any input price above $\hat{p}$, the technology will not be utilized.

2.2 Long-Run Equilibrium: Technology Decision

Now we turn to the long-run investment choice, in which the agent chooses efficiency to maximize long-run expected welfare. The long-run problem can be expressed as

$$\max_a W^{LR} = \int_{\underline{p}}^{\hat{p}(a)} \left[B(x^*) - pax^*\right] f(p;\theta)dp - z(a), \tag{7}$$

where x^* is the short-run optimal utilization given in equation (3). The first term in equation (7) is the net benefit of efficiency in states of nature when it is economic to utilize the technology. Expenditure on conservation technology is incurred in all states of nature.

The optimality condition for the long run-problem is

$$\frac{\partial \hat{p}}{\partial a}\left[B(x(\hat{p},a)) - \hat{p}ax(\hat{p},a\right] + \int_{\underline{p}}^{\hat{p}(a)} \frac{\partial x(p,a)}{\partial a}\left[B'(x^*) - pa\right] - px^* f(p;\theta)dp - z'(a) = 0. \tag{8}$$

By definition of $\hat{p}$, the first term in (8) is zero and by the short-run first order condition, the second term in (8) is zero. Thus, (8) simplifies to

$$\int_{\underline{p}}^{\hat{p}(a)} px^* f(p;\theta)dp + z'(a) = 0, \tag{9}$$

implicitly defining the long-run optimal input-output coefficient, or conservation. This condition says that at the optimal level of conservation, the expected value of marginal product (VMP) of conservation equals the marginal cost of the conservation technology.

2.3 Marginal Impact of Changes in the Distribution of Input Price

Using this model, we analyze how policy shocks to the probability distribution of input price affects choice of conservation technology. Totally differentiating the long-run optimality condition in (9), yields the comparative static

$$\frac{da}{d\theta} = \frac{-\int_{\underline{p}}^{\hat{p}(a)} px^* \frac{\partial f(p;\theta)}{\partial \theta} dp}{SOC_{LR}}, \tag{10}$$

where SOC_{LR} is the long-run second-order condition, which is negative for an interior maximum.

We cannot sign equation (10) directly using the standard stochastic dominance ranking theorems because the expected VMP of conservation may increase or decrease with p. This follows from the fact that x^* and p move in opposite directions. However, manipulation of equation (10) will uncover cases in which we can determine the direction of changes in conservation expenditure from changes in policy.

Integrating equation (10) by parts yields,

$$\frac{da}{d\theta} = \frac{\int_{\underline{p}}^{\hat{p}(a)} \left(\frac{\partial x^*}{\partial p} p + x^*\right) \frac{\partial F(p;\theta)}{\partial \theta} dp}{SOC_{LR}}. \tag{11}$$

Define the elasticity of utilization with respect to input price as

$$\epsilon_x = \frac{\partial x^*}{\partial p} \frac{p}{x^*}. \tag{12}$$

Substituting ϵ_x into (11) yields

$$\frac{da}{d\theta} = \frac{\int_{\underline{p}}^{\hat{p}(a)} (\epsilon_x + 1) \frac{\partial F(p;\theta)}{\partial \theta} dP}{SOC_{LR}}. \tag{13}$$

Suppose that for all prices, $\frac{\partial F(p;\theta)}{\partial \theta} \geq 0$, with the inequality being strict in some region. If acreage is elastic with respect to input price ($\epsilon_x < -1$), conservation increases. The opposite is true in the case where acreage is inelastic with respect to the input price.

This result is consistent with the stochastic dominance ranking theorems of Rothschild and Stiglitz (1970). If $\epsilon_x < -1$, then VMP of conservation is decreasing in p. Formally,

$$\begin{aligned} \frac{\partial VMP}{\partial p} &= \left(\frac{\partial x^*}{\partial p} p + x^* \right) \\ &= (\epsilon_x + 1) < 0 \qquad \text{if } \epsilon_x < -1. \end{aligned} \tag{14}$$

When the input price increases, there two effects on VMP. The increase in p directly increases the marginal productivity of conservation by increasing the cost savings. There is also an indirect effect on productivity that works in the opposite direction: an increase in p decreases x^*, which decreases marginal productivity of conservation. In the case where utilization is highly responsive to short-run realizations of input price, the indirect effect dominates the direct effect and VMP is decreasing in p. Since the assumed change in the distribution of input price corresponds to first-order stochastic dominance, it follows that an upward shift of $F(p;\theta)$ decreases VMP and reduces the incentive to adopt conservation technology. The opposite result holds for the case where $\epsilon_x > -1$

Of course, the assumption of first-order stochastic dominance is quite restrictive, although useful as a place to start the analysis. To sign the effect of other types of changes in the distribution of input price, it is helpful to establish whether VMP is concave or convex with respect to p. Consider first the case where $\epsilon_x > -1$. We have already established that VMP is increasing in p when the elasticity of utilization is small in absolute value. Taking the second derivative of VMP with respect the input price yields

$$\frac{\partial^2 VMP}{\partial p^2} = \left(\frac{\partial^2 x^*}{\partial p^2} p + 2 \frac{\partial x}{\partial p} \right) \tag{15}$$

From equation (5) it follows that $\frac{\partial x}{\partial p} < 0$ and $\frac{\partial^2 x^*}{\partial p^2} = 0$. Thus, VMP of conservation is increasing and concave in p when ϵ_x is smaller than unity in absolute value. Similar reasoning shows that VMP is decreasing and convex in p when $\epsilon_x < -1$.

With these intermediate results in hand, we can consider the marginal impacts of changes in the distribution of input price that are less extreme than first-order stochastic dominance. In particular, we can sign the impacts of a mean-preserving decrease in the variance of input price. This case is especially interesting as it captures the effect of conservation technology adoption when policy stabilizes resource supplies.

This corresponds to the real-world situation examined in the empirical section of this paper. We consider the effect of changes in the probability distribution of water price on production of permanent and annual crops. In the short-run, permanent crop production is relatively unresponsive to water price, while annual crop production is relative responsive to water price. In the case of permanent crop production, a mean preserving decrease in the variance of input price increases the expected VMP of conservation, and increases investment in conservation technology. This result follows from the ranking theorem of Rothschild and

Stiglitz since we have established that expected VMP is increasing and concave in p in this case. When acreage is highly responsive to short-run realizations of input price, a mean-preserving decrease in the variance of input price decreases the invest in irrigation technology improvements. Again, this result follows from Rothschild and Stiglitz.

This analysis establishes that changes in the distribution of input price, regardless of whether they follow from policy reform or construction of infrastructure, may have an ambiguous effect on the incentives to improve efficiency. In particular, we have shown that the direction of the effect depends to a large extent on the utilization response to short-run fluctuations in the input price. In the case of agriculture, if an irrigator produces a permanent crop, such as trees or vines (or even an annual crop that is grown under a long term production contract), then a first-order stochastic dominant decrease in the input price will reduce the incentive to invest in water-conserving technology. A mean-preserving decrease in the variance of input price will increase the incentive to invest in efficiency improvements. When the irrigator produces an annual crop, by contrast, the opposite results hold. In the following section, we test these predictions using data from the Arvin-Edison Water Storage District in the southern San Joaquin Valley of California.

3 Empirical Analysis

In this section, we test the relationship between investment in conservation technology and the probability distribution of the price of water. The null hypothesis that we test is based on the model in the previous section. In particular, we test whether a mean-preserving decrease in the variance of water price affects adoption of water-conserving irrigation technology.

Rejecting the null hypothesis would demonstrate that the price distribution has an effect on adoption of water-conserving irrigation technology and support the theory presented in Section 2.

The data used in this section was collected from the Arvin-Edison Water Storage District by Green and Sunding (1997). Arvin-Edison is located in the southern San Joaquin Valley in California. The data set is unique in that the unit of observation is an agricultural field. Having information at this level allows us to control for field-level heterogeneity which is important to agricultural production decisions, particularly for irrigation technology choice.(Caswell and Zilberman 1986, Green and Sunding 1997) The data set includes information about the technology, crops produced, and agronomic characteristics of the fields. An ordered probit regression is used to estimate the probability of adopting water-conserving irrigation technology.

3.1 Empirical Model

Expenditure on conservation technology is not directly observed in this data set, however, we observe the type of irrigation technology employed by the producer on each field in the sample. Irrigation technology efficiency is measured in terms of evapotranspiration per unit of water applied. In general, irrigators can chose three types of irrigation technologies: gravity, high pressure or low pressure irrigation technologies. Gravity irrigation includes the "traditional" technologies such as furrow or flood irrigation systems. These technologies are the least efficient. High pressure technologies include sprinkler technologies such as center pivot and mechanical-move sprinklers. Sprinklers have a medium level of efficiency. Low pressure technologies include drip and microsprinkler irrigation systems. These are the most efficient. These technology choices are ordered in terms of efficiency as well as cost. The least efficienct systems (gravity) are the least expensive while the most efficient systems (low pressure) are the most expensive.[1]

We can make inferences about the irrigator's preference for conservation by analyzing the choice of technology. Although the technology choice is discrete, ordering the technology choice by efficiency reflects the ranked nature of the choices in terms of conservation. Let T^* represent the level of expenditure on conservation technology and assume that it is a linear function of net benefits from investing in conservation technology, that is,

$$T^* = \beta'\mathbf{x} + \epsilon$$

where x is a matrix of the explanatory variables, β is a vector of coefficients and ϵ is the error term, which is assumed to have a standard normal distribution.

We do not observe expenditure on conservation technology, but we do observe technology choice, which can be defined in terms of T^*:

$$T = \begin{cases} 0 & \text{if } T^* \leq \mu_1 \\ 1 & \text{if } \mu_1 < T^* \leq \mu_2 \\ 2 & \text{if } T^* > \mu_2 \end{cases}$$

where $T = 0$ indicates gravity technology is observed, $T = 1$ indicates high pressure technol-

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[1] See Caswell (1983) for a detailed description of irrigation technology used in California agriculture.

ogy is observed, and $T = 2$ indicates low pressure technology is observed. The parameters μ_1, μ_2, and μ_3 are unknown parameters which are estimated. The μ's represent the cut-off points in the distribution for each choice of technology.

We estimate the following probabilities:

$$
\begin{aligned}
Prob(T = 0) &= \Phi(\mu_1 - \beta' x) \\
Prob(T = 1) &= \Phi(\mu_2 - \beta' x) - \Phi(\mu_1 - \beta' x) \qquad (16) \\
Prob(T = 2) &= 1 - \Phi(\mu_2 - \beta' x)
\end{aligned}
$$

Equation (16) provides the structural model for the ordered probit estimation of the probability of adopting water-conserving technology. In the following sections we describe our data and estimation results.

3.2 Data

The data used in this analysis is a sample of 1,224 agricultural fields serviced by the Arvin Edison Water Storage District. The data set includes information on soil characteristics, irrigation technology and water source for 92,294 acres of land in 1993. It was compiled from customer records maintained by the district.

The data set categorizes irrigation technologies used in the district into three categories: gravity, high pressure and low-pressure technologies. We estimate the probability of adopting conservation technologies using this discrete, ordered variable. Next we consider the variables we use on the right hand-side of our estimation model.

Caswell and Zilberman (1986) show that soil quality is an important determinant of irrigation technology adoption. To control for the effect of soil quality on the decision to adopt irrigation technology, we included two soil quality variables in our estimation: soil permeability and field slope. Soil permeability is measured in inches per minute and describes how fast the soil drains, or conversely, how poorly it retains moisture. Because pressurized technologies can distribute water more evenly over time, these technologies may help improve the soil's water storage capacity relative to gravity systems. Thus we expect soil permeability to have a positive effect on adoption. Field slope describes the grade of the field. This variable is measured as a percentage, where a higher percentage indicates a steeper slope. Since gravity irrigation technologies are difficult to implement on sloped fields, we would expect slope to have a positive effect on adoption of pressure technologies.

The data also includes the size of each field in acres. Field size can be used to control for scale economies in technology adoption. If there are scale economies associated with conservation technology adoption, we would expect the probability of adoption to increase with field size. Summary statistics for field characteristics are given in Table 1.

The crops included in this data set are citrus, deciduous, vine, and truck crops.[2] Because we are interested the difference between in response to a change in the variance of water price by crop types, we categorized crops into permanent and annual crops. Permanent crops in the data set include citrus, deciduous, and vine crops. Truck crops make up the annual crop category.

It is important to note that in agriculture, the technology choice may be closely tied to the crop choice. Because of this possible endogenous relationship between crop choice and

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[2] Truck crops include lettuces, processing tomatoes, and carrots.

technology, we tested the model for exogeneity of crop choice. We could not reject exogeneity at the 5 percent level. We conclude that crop choice may be mildly endogenous in this model, however, we did not have an adequet instrument to control for this. Consequently, our estimates may be slightly biased.

In Arvin-Edison, irrigators receive either ground or surface water.[3] Water rates in the district are set so that the mean input price (including lift for ground water users) is the same for both service areas. However, ground water levels are variable, and the price of ground water fluctuates from year to year. Surface water prices and delivery amounts are constant in the district, owing to Arvin-Edison's extensive conjunctive use facilities.[4] Thus, relative to the ground water service area, the distribution of water price in the surface water service area has the same mean but a lower variance. Thus with this data set, we can analyze the effect of a mean-preserving decrease in the variance of water price on conservation choice by considering the effect of switching from ground water service to surface water service.

The data set denotes the source of water to the field as a binary variable (*Reliability*), which is coded as 1 if the field receives the more reliable surface water and 0 if the field receives ground water. The conceptual model in the Section 2 predicts that the effect of switching from ground water to surface water may increase the incentive to adopt pressure technology for permanent crop growers, and may decrease the adoption incentive for annual crop growers. We estimate the effect of switching from ground water to surface water service areas on technology choice and control for field size and soil quality.

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[3] Surface water delivered by the district may be from ground water sources, but what we call surface water users are users who do not pump ground water directly. Ground water customers pump ground water directly.

[4] In the past two decades, water prices and water availability have not changed at all in the surface water service area.

3.3 Estimation Results

Following the conceptual model developed in Section 2, we consider the impact of a mean-preserving decrease in the variance of the price of water on technology adoption. We estimated the probability of adopting a conservation technology using an ordered probit. Our model included service area, crop choice, an interaction dummy variable for service area and crop, soil permeability and slope as regressors.

Table 2 presents the ordered probit estimation of water-conserving technology results for fields in permanent crops. All the explanatory variables expect soil permeability the dummy for reliability are statistically significant at least at the one percent level. The interaction dummy (reliability*crop) for service area and crop type is statistically significant. Reliability and the interaction dummy are jointly significant at least at the 1 percent level. Interpreting the coefficients from the ordered probit estimation is more intuitive when we consider the marginal effects.

Although the reliability by itself is not significant, the service/crop interaction variable is highly significant and the two variables are jointly significant. These results provide evidence in support of our model: the type of activity and uncertainty matter in the technology choice. To examine how much service area and crop choice matter, consider the discrete effect for permanent and annual crops are computed in Table 3.

In Table 3, we consider how the probability of adopting each of the three types of technologies changes when the field switches from ground water service area (relatively volatile) to surface water service area (relatively reliable). For fields in annual crops, decreasing price volatility *decreases* the probability of adopting low pressure technologies by 5 percent. The effect on high pressure technologies is negative but small. This corresponds to the case where elasticity of utilization is relative low. Looking at the results for fields in permanent crops, we find that a shift to a less volatile price distribution *increases* the probability of adopting low pressure technologies by nearly 12 percent. These results suggest that input price uncertainty has a large influence on adoption of conservation technology and that these effects depend on the type of economic activity.

Now we evaluate the effects on the continuous variables. Table 4 computes the elaticities of the probability of adopting each of the technologies with respect to the continuous variables. All the variables are evaluated at the sample means. The effect of field size is positive. Conserving technology is more likely to be adopted on a larger field. This reflects the possible economies of scale associated with adopting newer technologies. Soil permeability is positive. One would expect better draining soil to be more conducive to pressure technologies, however the coefficient is not significantly different from zero. Slope is positive and significant. More sloped fields are more likely to have pressure technologies since gravity is difficult to implement on slopes.

4 Conclusion

In this paper we explore the impact of input price uncertainty on conservation technology adoption and model technology as putty-clay. The theoretical model developed shows that, unlike the option value literature, the impact of increasing price uncertainty can have an ambiguous effect on adoption of conservation technology. We show that the level of activity responsiveness to input price determines the effect of price uncertainty on conservation technology adoption. We also extend the technology adoption literature lead by Hausman (1979) and Caswell and Zilberman (1985) by introducing price risk into the adoption decision.

An empirical analysis of irrigation technology adoption the San Joaquin Valley supports our model. Our empirical analysis predicts that a mean preserving decrease in input price variability can increase or decrease adoption. When the agent produces an annual crop, a mean-preserving decrease in price variability decreases adoption of conservation technology. When the agent produces a permanent crop, which is less responsive to input price changes, a mean-preserving decrease in price variability increases adoption.

The policy implications of our result are two-fold. First policy makers should consider reliability and conservation policy as jointly. As our results indicate, response to conservation may differ for different types of production choices, i.e. permanent versus annual crops. Second, policy makers can use results from the model presented in this paper to more effectively target regulation to encourage resource conservation. This may become particularly important in energy markets. As deregulation of energy markets continues increasing price volatility may result, as has been observed in California ((McCullough 1999).

Variable	Mean	Standard Deviation	Minimum	Maximum
Soil Permeability	2.89	3.00	0.13	13
Slope	1.58	1.32	0.50	10
Field Size	50.78	52.66	1	490

Table 1: Summary Statistics for Field Characteristics

Variable	$\hat{\beta}$	Standard Error	P-value
Reliability (0/1)	-0.1297	0.1339	0.333
Reliability*Crop (0/1)	0.5112*	0.1546	0.001
Field Size	0.0027*	0.0007	0.000
Permeability	0.0055	0.0120	0.646
Slope	0.3948*	0.0314	0.000
Permanent(0/1)	-0.3170*	0.1060	0.003

*Statistically significant at the 99% level

Table 2: Ordered Probit Estimation Results

Technology	Annual Crop			Permanent Crop		
	Predicted Probability		Discrete Effect*	Predicted Probability		Discrete Effect*
	Ground Water	Surface Water		Ground Water	Surface Water	
Furrow	0.3674	0.4173	0.0498	0.4914	0.3633	-0.1281
Sprinkler	0.2446	0.2434	-0.0012	0.2349	0.2445	0.0096
Drip	0.3879	0.3393	-0.0486	0.2737	0.3922	0.1185

*Change in probability of adopting when switching from ground to surface areas.

Table 3: Adoption Effects for Annual and Permanent Crops

Elasticities	x_i		
	Field Size	Soil Permeability	Field Slope
Furrow	-12.75	-1.50	-58.76
Sprinkler	1.20	0.14	5.52
Drip	14.48	1.71	66.74

Table 4: Elasticities Evaluated at the Sample Means

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