IPM Adoption: Motivations, Barriers, and Subjective Risk Assessments in Contract Agriculture

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Introduction

❖**Objective:** This project is aiming at investigating barriers and finding potential incentives of the adoption of the Integrated Pest Management (IPM).

❖**Motivation:** The traditional way of using pesticides as main tactics of controlling pest triggers environmental and human health considerations. In addition, intensively and repeated using of pesticides impose the risk of resistance of pesticides.

❖**Integrated Pest Management(IPM):** The USDA defines IPM as "…management approach that encourages natural control of pest populations by anticipating pest problems and preventing pests from reaching economically damaging levels. All appropriate techniques are used such as enhancing natural enemies, planting pest-resistant crops, adapting cultural management, and using pesticides judiciously." (USDA, Agricultural Research Service 1993)

❖**Difficulty:** Several reasons explaining the possible difficulties of IPM adoption. First, IPM is not as precise comparing with traditional chemical intensive pest management. Second, IPM is a complex, knowledge-intensive technology, which is relatively harder for growers to implement. Third, the natural conditions of outside areas of crop growing are harder to control (temperatures, natural enemies etc.) when implementing IPM.

❖**Production Risk:** Due to the difficulties stated above, IPM may be less efficient in pest eradiation, therefore, production risk may increase with a higher level of IPM adoption.

Background

In the United State, the growing of hops mainly concentrated in the Pacific Northwest and on family owned and operated farms. The majority of hop farms are located in Washington's Yakima Valley. In 2008 for example, Washington State produced 30,595 acres of hops, which made up about 75% of the US commercial hop's production. Behind Washington was Oregon with 6370 acres and Idaho with 3933 acres which make up around 15.5% and 9.5% of the US commercial hop production respectively.

Model

• **Timeline:** In the contract stage, the hop buyer offers a multi-year forward contract that specifies the hop price per pound ($\bar{p}$), purchase quantity (i.e. contract size) ($\bar{y}$), and the hop quality level ($\bar{q}$). Given the contract, the representative hop grower makes decision on quantity inputs level(X), where we assume the corresponding input price vector is (P_X). In the transaction stage, the hop buyers decide whether to accept the subject hop, or renegotiate the price according to the quality output (q). In other words, if the hop quality doesn't meet the level, i.e. $q < \bar{q}$, renegotiation may result where the buyer offers a downgraded hop price $\tilde{p} < \bar{p}$.

<u>Contract Stage</u>		<u>Production Stage</u>		<u>Transaction Stage</u>
Merchants offer a forward contract ($\bar{p}, \bar{y}, \bar{q}$)	→	Grower choose inputs to produce hops given contract (X)	→	Merchants accept or renegotiate the subject hop with price $\tilde{p} < \bar{p}$

•**Technology**

We assume Z is a vector representing the standard input of production. X^c is a vector of chemical inputs for pest control agents; X^b is a vector of biological based pesticides and labor use of pest control practices designed in IPM program.

The stochastic production function for hop quality is,

$$q = H(Z, X^c, X^b, \varepsilon)$$

where the disturbance term ε represents common stochastic production shocks, such as the pest infestations during hop production process. It is assumed to follow a subjective distribution with the probability distribution function $f(\varepsilon)$ and are statistically independent with $E(\varepsilon \mid X) = 0$.

•**Hop Growers' Decision Under a Forward Contract**

We shall consider a two states setting in which grower derives utility from a nonstochastic profit $\pi_1 = \bar{p} \cdot \bar{y} - P_X X$, if the subject hops got accepted; and $\pi_2 = \tilde{p} \cdot \bar{y} - P_X X$, if renegotiation occurs due to the quality issue, where a downgrade hop price is received.

The grower makes decision on the pest control input level (i.e. intensity of IPM adoption) by simply maximizing the expected utility over these two states,

$$\max_{\{X\}} EU = \int_{\bar{q}}^{b} f(q \mid Z, X^c, X^b) dq \cdot U(\pi_1) + \int_{a}^{\bar{q}} f(q \mid Z, X^c, X^b) dq \cdot U(\pi_2)$$

The first order condition can be approximated as,

$$\frac{\partial EU}{\partial X^{i*}} \cdot \frac{1}{U'(E\pi)} = \int_{\bar{q}}^{b} \frac{\partial f(q \mid Z, X^{i*}, X^{-i})}{\partial X^{i*}} dq \cdot \left[\Delta\pi + \frac{1}{2}(-\bar{R})(\Delta\pi)^2 \left(1 - 2\int_{\bar{q}}^{b} f(q \mid Z, X^{i*}, X^{-i}) dq\right)\right] - P_{X^i} = 0, i = c, b$$

where $\bar{R}$ represents the Arrow-Pratt measure of absolute risk aversion (ARA) evaluated at the mean profit. And $\Delta\pi$ represents the difference of profit levels between the two states, and it is exogenously determined.

It thus suggests that several factors affect the grower's optimal input choice, thus the intensity of IPM adoption: the grower's risk attitude; the marginal effect of input on probability of acceptance; and the difference of profits between the two states.

•**Conjectures Regarding the Contract Size**

Conjecture 1. *A larger contract size provides incentive to increase (decrease) the use of a risk-decreasing (risk-increasing) input.*

Conjecture 2. *As risk aversion increases, the response of increasing the risk-decreasing input to increases in is more positive.*

Data

❖**Survey**

A survey was carried out in order to collect data of hop grower's input use, as well as grower's social demographic characteristics.

The survey targeted the whole population of around eighty hop growers in Pacific Northwest and it will be conducted in April 2012. The email-out questionnaire contains three parts: the hop production information, the pest management practices and growers' demographic information.

❖**Experiment**

Increasing production risk is believed to be a critical factor influence on IPM adoption under risk aversion. In order to elicit the hop growers' risk perceptions, an experiment was conducted where individual is asked to make decision between two lotteries.

Risk-preference parameters can be estimated from this experiment, where we would expect that hop growers in the Pacific Northwest exhibit decreasing absolute risk aversion (DARA).

Empirical Method:

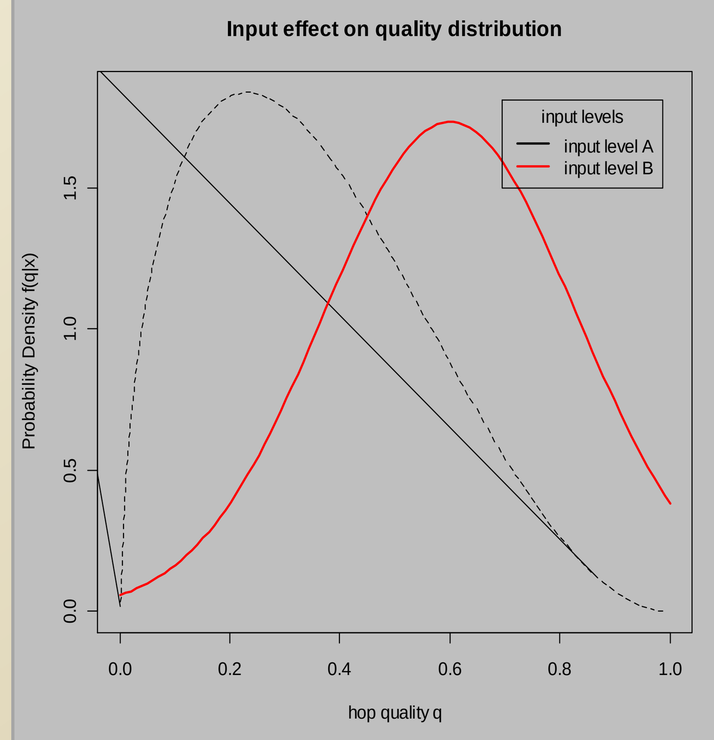
•**Utility Function**: To further operationalize the framework, we assume a hybrid "power-expo" utility function

$$U(x) = \frac{1 - \exp(-\alpha x^{1-r})}{\alpha}$$

• **The Marginal Effect of Input on the Quality Distribution:**

1.We utilize the partial moment approach to capture the marginal effect of an input on the quality distribution truncated about $\bar{q}$

2. Partial moment approach allows the flexibility to characterize the different effects of an input on the positive and negative tails of quality distribution.



The negative partial moments:

$$\mu_i^-(x, \bar{q}) \equiv \int_a^{\bar{q}} \{q - \bar{q}\}^i f(q \mid x) dq$$

The positive partial moments:

$$\mu_i^+(x, \bar{q}) \equiv \int_{\bar{q}}^{b} \{q - \bar{q}\}^i f(q \mid x) dq$$