Weather Index-based Crop Insurance as an Adaptation Strategy to Climate Change in Chile

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Background

IPCC indicates that many ecological systems are affected by regional climate changes. **Agriculture is particularly sensitive** to these changes, because of their climatic dependence. Experts have projected that climate change will generate impact on water flows in Chile and . And there will be an increase the frequency of hydrological droughts, which would affect irrigated agriculture

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Considering the uncertainty regarding Climate Change scenarios, the implementation of climate change adaptation measures becomes an important strategy (Di Falco et al., 2013). Several studies have focused on adaptation measures as an alternative to manage the risks associated with climate change (Smitt and Skinner, 2001).

In the light of this situation the question that arises is: **"What strategy can farmers use to protect themselves from crop production uncertainty caused by Climate Change?**

Problem

- The analyzed Weather Index-based Insurance Model incorporated a **Just-Pope stochastic production function** to design an optimal insurance contract. However, a Just-Pope function is limited to the first two moments of the output distribution, and the marginal effect of an input on all higher central moments central moment is the same as its effect on the second .
- We consider a **more flexible stochastic production function specification** in order to analyze input uses and producer's preferences for right skewed distributions.

Methodology

1. First, we highlighted the main features of an insurance based on a weather index.
2. Secondly, we extended the analysis of an insurance model, previously proposed in the literature, by incorporating a flexible specification of the stochastic production function.
3. Finally, We compared both models.

Goals

This study analyzes a Weather Index-based Insurance for agriculture as an **adaptation measure to protect farmers against an increasing uncertainty of available water flows.**

1. To analyze its behavior with the flexible specification of the stochastic production function on the insurance model.
2. To verify the applicability of this type of insurance, regarding definitions of risk increasing inputs and risk decreasing inputs, considering risk aversion and prudence.

Weather Index-Based Crop Insurance

A Weather Index-based insurance is an insurance in which indemnity payments are based not on actual losses experienced by policyholders (farmers) but rather on the realization of a weather index threshold that is highly correlated with actual losses. (Barnett and Mahul, 2007).

In a scenario of risk exposure, this type of insurance could **help farmers stabilize net income,** and it could also be an important tool for the development of smallholder farmers.

A Flexible Production Function

We considered a flexible stochastic production function that allows for independent marginal effects of inputs on the central moments of the production distribution.(Moment-Based Approach, Antle, 1983)

$$\tilde{y} = \tilde{\omega} + k(x)\tilde{\varepsilon} + h(x) \quad (1)$$

It is assumed that producers maximize their expected von-Neumann Morgernstern utility of stochastic wealth (Mahul, 2001):

$$Eu(\pi_0 - px + \tilde{y} + I(\tilde{\omega}) - P)$$

P:insurance premium
I:indemnization
x:inputs
P:prices

Subject conditions to:

$$Ev\left[w_0 + P - I(\tilde{\omega}) - c\left(I(\tilde{\omega})\right)\right] \geq v(w_0) \quad (2)$$

$$I(\omega) \geq 0 \qquad \forall\ \omega \quad (3)$$

Input Use under Risk Aversion and Prudence

Preference with respect to moments:

- We employ a third order Taylor-series expansion: of von-Neumann Morgenstern utility (Chavas, 2004):

$$EU(W) \approx U\left(E(W)\right) + \sum_{i=1}^{3}\left[\frac{1}{i!}\right]U^{i}\mu_i$$

- The Risk Premium (P) is thus:

$$(a)P_r \approx \sum_{i=2}^{r}(-1)^{i}R_i\mu_i \quad (b)P_r \approx \frac{R_2}{2}.\mu_2 - \frac{R_3}{6}\mu_3.$$

Risk Properties of Inputs

- Third order approximation of the marginal risk premium due to a marginal change in an input (*x*) is

$$P_r \approx \frac{R_2}{2}.\mu_2 - \frac{R_3}{6}\mu_3.$$

Proposition For all risk averse and downside risk averse producers, the marginal risk premium is negative if and only if the input is risk-decreasing. That is:

$$P_{rx} < (>)0 \leftrightarrow \frac{\partial \mu_1(\hat{x})}{\partial x} = p$$

Results

Considering Proposition 1 (See Mahul, 2001), the optimal indemnity is:

$$I^{*}(\omega) = 0;\ \text{if}\ \omega \geq \hat{\omega}$$
$$I^{*}(\omega) > 0;\ \text{if}\ \omega < \hat{\omega}$$

When I*(ω) , the marginal coverage is:

$$\left\{\omega_\omega \int_{\varepsilon_{min}}^{\varepsilon_{max}} u''(\pi)d\Psi(\varepsilon|\tilde{\omega}=\omega) + \int_{\varepsilon_{min}}^{\varepsilon_{max}} u'(\pi)d\Psi_\omega(\varepsilon|\tilde{\omega}=\omega)\right\}\frac{1}{\Sigma} < 0$$

Similar implications to Mahul (2001)

$$\Sigma = -\int_{\varepsilon_{min}}^{\varepsilon_{max}} u''(\pi)d\Psi(\varepsilon|\tilde{\omega}=\omega) + \int_{\varepsilon_{min}}^{\varepsilon_{max}} u'(\pi)d\Psi(\varepsilon|\tilde{\omega}=\omega)\left[\frac{c''}{1+c'}(1+c')A_v(w)\right]$$

$$A_v(w) = \frac{-v''}{v}$$

Input Uses and Insurance in Two Different Scenarios:

Without Insurance

When the producer does not buy an insurance contract, the optimal level of input X that satisfies the first-order condition is:

$$U_x(x,0,0) = h'(x^{ni}) + t - p = -\frac{\text{cov}\left(\hat{u}'\left(\pi_{ni}(x^{ni})\right), \omega_x(x^{ni})\right)}{E(\hat{u}'(\pi_{ni}(x^{ni}))}$$

Different implications to Mahul (2001)

With Insurance

When the producer buys an insurance contract, the optimal level of input X that satisfies the first-order condition is:

$$h'(x^{i}) + t - p + \frac{cov\left(\hat{u}'\left(\pi_i(x^i)\right), \tilde{\omega}_x(x^i)\right)}{E(\hat{u}'(\pi_i(x^i))} - \omega_{\omega x}\frac{cov\left(\hat{u}'\left(\pi_i(x^i)\right), J(\tilde{\omega})\right)}{E(\hat{u}'(\pi_i(x^i))} = 0$$

Conclusions

This specification allows for a more precise classification of an input as risk-increasing or risk-decreasing. An input's marginal impact of production risk affects the optimal insurance contract level and vice versa. Our results suggest that a weather index-based insurance for hydrological drought risk could be an effective adaptation strategy to climate change for irrigated agriculture.

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