Can Farmers Savings Accounts be secured for Extreme Weather Events?

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OBJECTIVES

The purpose of this paper is to design a hybrid savings-weather derivative program that can be used as a risk management tool by crop producers.

THE PROBLEM

Farm savings accounts programs have been discussed in the literature in last years (Gloy, et al. 2005, Monke and Dursy, 2002). These programs have been created to help farmers to manage different types of risk and provide a safety net (Edelman, et al. 2001, and Edelman, et al. 2001b).

The general idea behind these programs is that people are prudent and substitute consumption with savings because future income is uncertain (Gollier 2002 and 2003). However, the problem with the levels of farmers' saving balances is that they may not be accumulated fast enough to deal with extreme events, e.g. due to weather.

The timing of the events can be such that there is not enough money accumulated in savings accounts when these events happen. For example, a sequence of two or three shocks in a row may deplete savings accounts to the point where the savings are not big enough to maintain an adequate standard of living. Some authors propose that the government serves as a back stop for these types of losses. However, considering that most of these events are associated with extreme weather conditions we propose a weather derivative as an alternative back stop.

Steit and Tobacman (2012) try to develop a laboratory experiment to evaluate Indian farmers' preferences for savings and insurance based on a 2-period model. They consider savings and weather derivatives as substitutes. It means that farmers could redirect money from an instrument to another without any penalty. In our case, savings are the dominant account and weather derivatives serve as a back stop only. Furthermore, we develop a dynamic discrete-time stochastic model for more than 2 periods.

THE MODEL

Consider a farmer who is an expected utility maximizer with a planning horizon from $t = 1$ to T. At the period t, the farmer receives random revenue y_t from crop activities. We assume that farmers save an amount d_t at the interest rate r in a saving account and derive utility from the leftover $y_t - d_t$. In a given year, the farmer may withdraw their savings under certain conditions. More specifically, if $y_t < \alpha\bar{y}$, the farmer can withdraw the different $\alpha\bar{y} - y$ until certain proportion.

The balance of his saving account s at period $t + 1$ would be The measure of utility may depend on the type of production and may include factors like cost.

$$(1) \qquad s_{t+1} = (1 + r)(d_t + s_t) - (\alpha\bar{y} - y)$$

Farmers are exposure to random losses. Some of these are small with high frequency and others are rare but huge. We assume that an extreme weather derivative contract is attached to the saving account. This contract pays I_t only when the trigger weather measurement i_t falls below to extreme level $\bar{\imath}$. The balance of his saving account s at period $t + 1$ would be

$$(2) \qquad s_{t+1} = (1 + r)(d_t + s_t) + \mathbb{1}(y_t < \alpha\bar{y}) \times (\alpha\bar{y} - y) + \mathbb{1}(i_t < \bar{\imath})I_t$$

The indicator function $\mathbb{1}(A)$ takes the value of one if the condition A is satisfied, and zero otherwise. The premium is paid at regular basis. The decision problem of the consumer is to select a state-contigent deposit plan and insurance plan so that maximize the sum total of discounted expected utility over the planning horizon (i.e. the sum of all utilities the farmer is expected to derive from $y_t - d_t$ over a given number of periods expressed in present-day monetary units).

The optimal allocation strategy then has to satisfy the Bellman equation

$$(3) \qquad v(s_t) = \max_{d.,I.} \ u(y_t - d_t) + \beta Eu(s_{t+1})$$

subject to the budget constraint (2). Where β is a discount factor. Depending on the functional forms chosen to represent the farmers' utility function, the Bellman and/or Euler equations generally do not possess closed-form solutions. Thus, the optimal allocation strategies have to be found numerically. In this work, we assume a Constant Relative Risk Aversion power utility function. Solving this problem for each d_t yields the optimal state-dependent saving balance s_t together with the value function $v(\cdot)$.

Based on the first order condition of problem (3) and applying the envelope theorem we can derive the Euler equation and from it calculate the optimal path deposit plan $\{d_t\}_{t=1}^{T}$, and insurance plan $\{I_t\}_{t=1}^{T}$.

METHODOLOGY

We construct numerical solution program for the Bellman equation (3) describing the consumption/savings strategies. We use Monte Carlo simulation approach to construct the evolution of the optimal path of consumption and savings with and without the insurance. We compare the optimal consumption paths and evaluate the effect of basis risk on changes in optimal consumption allocation patterns. The class of Lower Partial Moments is also used a measure of income risk

DATA

This study is applied to cotton production in Texas. Weather Data are collected from databases of the National Climatic Data Center. Historical district-level yield data are collected from the USDA's National Agricultural Statistics Service.

RESEARCH QUESTIONS

- What are the optimal triggers for weather derivatives?
- What is the cost of the program?
- Are mandatory weather derivatives purchases better than optional?
- Will the program be actuarially sound from the insurer's perspective?

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