NAREA Workshop on Crop Insurance and Risk Management
Extended Abstracts

Identifying Risk Factors Affecting Weather and Disease Losses for a Farm-Raised Catfish Insurance Policy

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Aquaculture production poses many challenges due to the unique nature of the water production environment and the containment structures employed. This paper focuses on identifying and understanding risk factors affecting weather and disease losses on U.S. catfish farms. A better understanding of farm risk levels based on producer and/or farm characteristics, production practices and production region can help reduce risks and catfish losses. The National Risk Management Feasibility Program for Aquaculture hired the National Agricultural Statistics Service (NASS) to survey catfish producers to obtain historical loss information, farm characteristics and production practices. A survey conducted during July to August 2005 in 29 states provided 777 useable surveys from 1,201 catfish producers individually surveyed.

Two double-limit tobit models were used to determine relationships between the percent of catfish lost due to weather events or insurable diseases and observable producer/farm characteristics and production practices. Explanatory variables included in the weather loss model were farm spread (the greatest distance between the most remote pond and headquarters), pond water depth, number of ponds and a regional dummy variable; and explanatory variables used in the disease loss model included experience, education level, pond age, pond depth and number of ponds.

Preliminary results of the weather loss model indicate pond water depth (+ sign), number of ponds (+ sign), and South region (- sign) variables were statistically significant. Thus, as pond depth and pond number increased catfish losses from weather events would increase. The South variable's significance indicates fewer lost catfish from weather events in this region compared to operations in other regions (approximately 95% of all farm-raised catfish is produced in four southern states).

Preliminary results of the disease loss model indicated operator experience and pond water depth to be significant with negative signs. Thus, increased operator experience reduced disease-related catfish losses, an expected result. Also, education level was not significant indicating experience on the farm was a better indicator of reduced risk than education. The pond depth variable was significant and negative indicating that as pond depth increased, disease related losses would decrease. This negative sign is in contrast to the positive sign for this variable in the weather-related loss model, but from the model's elasticities it appears that disease losses are of much greater economic importance, so increasing pond depth should be chosen. Of additional note is the non-significance of farm size, which was thought to be an indicator of disease loss magnitude, but was not borne out by model results, which showed farm size and disease related losses are not as important as previously thought.

In conclusion, results of this research provide information on observable risk factors that can be used to evaluate catfish operations and assist them in reducing their risk and loss levels.

An Insurance Approach to Risk Management in the Ethanol Industry

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Value-added enterprises, such as ethanol production, have recently gained interest as tools farmers can use to create new markets for their products. According to the Renewable Fuels Association (2007), there are close to 100 ethanol production facilities operating in the United States comprising a total production capacity of more than 5.5 billion gallons. Additionally, the RFA reports over 80 plants that are currently under construction or in the process of expanding existing production capacity that will more than double production capacity by 2010. The vast majority of ethanol plants use corn as the feedstock in the production process, creating new markets for corn producers. In 2006, 4.4 billion gallons of ethanol were produced in the U.S. using nearly 1.6 billion bushels of corn, roughly 13% of total U.S. corn production. Moreover, a large proportion of existing plants are at least partially farmer owned through cooperative or LLC structures where membership "shares" are sold on a per bushel basis with a designated delivery requirement. In addition to payments received for marketing their corn to the plant, the farmer-owners generally receive dividend payments based on the profitability of the facility. Thus, while ownership in the facility guarantees a market for a proportion of the farmer's corn production, it also exposes the producer to additional price risk tied to global energy markets.

In March 2005, the Chicago Board of Trade (CBOT) introduced one of the first market-based risk management tools for the ethanol industry in the form of a futures contract for denatured ethanol. However, the trading history on the futures contract has shown relatively low trading volumes and little price volatility relative to cash market ethanol prices. Additionally, the market still lacks an exchange traded options contract on ethanol, further limiting the risk management options available to investors in the ethanol industry. The vast majority of crop and revenue insurance policies sold in the United States are single-crop policies that insure against low yields or revenues for each crop grown on the farm. But, increasingly, producer income is based more on the value of crops that have been converted into a value-added product. Insurance against declines in the value-added portion of the crop is not yet available.

This paper uses an insurance approach to outline a risk management tool for corn producers who have invested in an ethanol production facility. By insuring against circumstances that cause low profits for ethanol plants, the product will provide value to its owner during periods of low premium payments. The option mimics the gross margin level of a typical ethanol production facility that implements the dry-mill production process using corn as the feedstock. A variety of potential policy specifications are explored, and an historical analysis is used to assess potential product performance. The product is shown to perform as intended, paying indemnities in years of excessively high corn prices and/or low ethanol (energy) prices. The historical analysis illustrates the volatile nature of program payments. Potential insurance providers must be able to handle large losses in any contract period, while relying on temporal diversification rather than risk pooling in any single period. The relative performance of the insurance policy compared to other risk management strategies using the CBOT ethanol futures contract is also analyzed and discussed.

Modeling Exit and Entry of Farmers in a Crop Insurance Program

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The purpose of this paper is to investigate how weather and economic factors have an impact on farmer participation in soybean yield insurance in eight Ontario counties from 1988 to 2004. This paper contributes to the agricultural insurance literature by developing a conceptual model that studies the conditions under which past crop yield will have a negative or positive impact on crop insurance participation. Furthermore, while previous research has concentrated on the factors that affect the *joining* decision, our empirical analysis provides a richer understanding of the participation process by also studying the factors that affect the *exiting* decision. Using a unique data set from Ontario we develop four measures of crop insurance participation: total number of farmers in the scheme; number of farmers joining the program; number of farmers dropping out of the program; and the proportion of acres insured.

The empirical results illustrate how the effect of a given variable might be muted when participation is measured by aggregate measures. For instance, when we measure participation as the total number of farmers enrolled in a crop insurance program in a given year, the insurance premium rate seems to have little explanatory power; but when participation is decomposed into entry and exit, it is clear that entry decisions are more sensitive to changes in insurance premiums relative to exit decisions. In addition, the approach distinguishes between price and yield variables rather than total returns and is consequently able to demonstrate that price variables are particularly important for farmers considering enrolling in crop insurance. In turn, yield variables and other risk management opportunities are more important for farmers who have been in the program but are deciding to exit. The result suggests moral hazard is reduced significantly by calculating the coverage yield level for an individual producer on the basis of a moving average of past yields for that farmer. While yield and its variance are particularly influential in the participation decision for farmers currently enrolled, its significant

impact on the insurance decision for all farmers highlights the importance of crop insurance as a potential adaptation strategy to weather events. If increased awareness about changing weather patterns results in an increased level of farmer participation, it is important for insurance providers to investigate the effects of this increasing demand in the context of projected climate change. For instance, an increase in participation might mean more financial requirements and greater premium adjustments along other changes that might affect the long-term financial viability of the insurance provider.

A Comparison of Alternative Option Pricing Approaches For Weather Derivatives

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The weather markets have been growing rapidly since their introduction in 1997 and has exceeded a value of $7.5 billion in the US. The energy generating industry is the biggest trader accounting for 58.6%, followed by construction, 14.4%, and agriculture, 8.7%. 87% of the weather trade involves temperature in terms of heating or cooling degree days primarily and about 7% involves rainfall products.

Various weather derivatives (options) pricing models have been developed and there is a lack of consensus. Based on different assumptions about the behavior of the underlying weather variable and about the market, there are mainly two contrasting approaches: an extension of the original Black-Scholes (BS) model which is popularly applied in the weather derivative pricing and the hedger's indifference pricing approach. There are also ways of extending the BS model: the first one considers the temperature directly assumed to be mean reverting and follow Ornstein-Uhlenbeck process, while the second considers Brownian motion of the underlying weather index (degree-day measure). In this study we will empirically compare these alternative approaches by estimating the option prices using the three models using temperature data.

Black-Scholes Models under Browning Motion Assumption

A closed form options price is given as (1) for non-tradable asset, W_t^*, if it follows a Brownian motion and buyers and sellers are compensated for nontradable risk.

(1) $V_{call} = W_0^* e^{(\mu-\lambda\sigma)T}\Phi(d_1) - Xe^{-rT}\Phi(d_2)$ and $V_{put} = Xe^{-rT}\Phi(-d_2) - W_0^* e^{(\mu-\lambda\sigma)T}\Phi(-d_1)$

and $\mu_t = \ln\left(\frac{W_t^*}{W_{t-1}^*}\right)$, with mean μ and volatility σ. W_t^* is the expected value of the degree-day index on day $t \le T$, the maturity day, r is the risk free interest rate.

Black-Scholes Models under Mean Reverting Assumption

The temperature T_t is Q martingale $dT_t = \left\{\frac{dT_t^m}{dt} + a\left(T_t^m - T_t\right) - \lambda\sigma_t\right\}dt + \sigma_t dV_t$, where V_t is Q-Wiener process, T_t^m is the mean temperature, and σ_t is standard deviation Heating Degree Day call option price is of the form (2), and put can be expressed in a similar way, omitted here.

(2) $$V_{Call} = e^{-rT}\left[(\mu_n - X)\Phi(\alpha_n) + \frac{\sigma_n}{\sqrt{2\pi}} e^{\frac{\alpha_n^2}{2}}\right]$$

Indifference Pricing

The indifference hedger's price of the claim on the nontraded asset *f(x_T)* is defined as p^h such that the hedger is indifferent to: optimizing expected utility without using the derivative and optimizing expected utility taking into the expected payoff and cost.

(3) $$\sup_v Eu\left[w + \int_0^T v_t dS_t\right] = \sup_v Eu\left[w + \int_0^T v_t dS_t - kp^h + kf(x_T)\right].$$

Data used for this study are historical daily temperature series for 30 years for Portland, Oregon. We chose Portland for two reasons: CME weather derivative products are available for Portland, and it is the closest city for Washington agricultural producers whom we take as one trader in the indifference pricing model in empirical analysis. For the indifference pricing approach we use the data on energy prices for one scenario and wheat yield data for the second scenario.

Initial Results:

We have results for the first extension of Black –Scholes model for 4 different degree-day' contracts of varied lengths. The cooling degree-day contracts were 92-day call and put options with contract terms from June 1 with expiry on August 31 and 53-day call and put options with contract terms from May 1 with expiry on September 30. The heating degree-day contracts were 90-day call and put options with contract terms from December 1 with expiry on Feb28 and 151-day contracts with contract terms from November 1 with expiry on March 31. The tick value in the money was valued at $5000 per degree-day. At-the money strike is 345.16 for the 92-day contract and is 416.12 in the case of the 153-day contract. The call and put options are very close at the money and we find that call and put options moving in opposite directions as the strike prices go out of the money or in the money. Call options have positive values in the money while the put options have positive values out of the money. At the money call and put option value in the case of the 92-day contract was $107 and has very low value in the case of 153-day contract. The call option value is biggest with $1,206,079 at the strike price of 100 while the put option value is highest with $1,007,654 at the strike price of 550. Similar trends are found in the case of 153-day contract as well. We would like to compare these results with the results of the second extension of the Black-Scholes model and compare both with the indifferent prices which are applicable to buyers of weather derivatives only.

Preference for Crop Insurance and Risk Management Information Sources: Implications for Extension and Outreach Programming

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Introduction

The range of crop insurance products offered by the Risk Management Agency (RMA) has expanded from only providing traditional yield insurance; to now include revenue insurance products and products based on county rather than farm yields. All of the crop insurance products currently offered by the RMA have intrinsic characteristics, such as premium rate structures and specific coverage provisions that make them different from each other. These insurance product characteristics also make each product specifically suited to particular crops, geographical areas, and farmer risk management objectives. Given the variety of insurance products available, it then becomes important, from a management perspective, for farmers to be aware of and understand the attributes of those alternative products.

Given producers' need for information about alternative risk management tools, understanding the sources that they rely on for such information is important. Prior studies have focused on producers' demand for risk management education in general. However, there have been limited studies about the different socio-economic and farm business characteristics that affect demand for various types of information about alternative crop insurance products and other risk management tools. Understanding the factors that affect farmers' valuation of crop insurance or risk management information sources would help various institutions (e.g., the RMA and the Extension Service) effectively tailor their outreach and educational programs. Better targeting of educational efforts could help farmers improve their risk management skills and this could have a positive impact on their management decision making.

The objective of this study is to examine the factors that affect how farmers perceive the relative importance of alternative methods for learning about crop insurance and other risk management tools. Specific questions that this study will address are the following. (1) What do farmers consider their most important learning method in order to know more about crop insurance and other risk management tools? (2) Which producer characteristics influence the degree of preference among the different learning methods?

Data and Empirical Approach

This study will use data from a mail survey with geographic scope that includes farmers in Mississippi, Texas, Indiana, and Nebraska. A total of 6,810 surveys were mailed to crop producers prior to the 1999 planting season (spring) in each of the states. A total of 1,826 surveys were returned, out of these 1,812 were qualified as complete to be usable, resulting in an effective response rate of 27%. The survey targeted producers of major field crops: corn and soybeans in Indiana and Nebraska, cotton and soybean in Mississippi, cotton and sorghum in Texas and provided information about demographics, business characteristics, risk perception, alternative risk management practices, agricultural policy preferences and risk management educational preference. In the risk management section, responses from farmers provided rankings that indicated their preference for learning methods that gave them information about risk management tools. A Lickert type scale ranging from 1 (*low preference*) to 5 (*strong preference*) was used to provide the rankings. The learning methods ranked included information from: (1) risk management experts, (2) in depth materials to study on own time, (3) farm magazines or newsletters, (4) internet or other computer based education modules, and (5) marketing clubs or other groups of producers.

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Given that the dependent variable is an ordered discrete integer, the natural estimator of this type of model is an ordered probit or logit model estimated using maximum likelihood (ML) techniques. The ordered probit model is by far the most popular choice in analyzing ordinal response variables and this model is what we use in examining the factors that affect farmer's perceptions about the importance of risk management learning methods.

Summary of Results and Implications

Using simple descriptive statistics and histograms, we found that information from risk management experts, own materials (studied on his/her own), and farm magazines/newsletter tend to be preferred by majority of the surveyed producers. On the other hand, there is a large proportion of producers that does not seem to prefer information from the internet and from marketing clubs/other groups of producers.

Using an ordered probit model to investigate farmer/farm attributes that affect preference for a particular information source, we find that younger farmers with higher college education, higher leverage, assets greater than $1M, risk loving attitudes, and have used professional services (marketing consultants) tend to prefer information from risk management experts, the internet, and marketing clubs/other producers. On the other hand, our results suggest that producers who prefer self-study of educational materials and popular press information sources tend to be younger individuals with lower leverage levels and have used less professional services.

From an extension programming perspective, our results suggest that younger, well-educated farmers with larger operations (i.e. well leveraged and large asset base) and that are more willing to take risks will be the ones more responsive to the typical delivery mechanisms being used by risk management extension educators – in-depth training by risk management experts and internet delivery of educational materials. On the other hand, there is some indication form our results that younger producers with smaller operations may tend to prefer self-study of educational materials and popular press. Given these results, a risk management extension educator can feasibly structure his/her program by using in-depth training and internet delivery mechanisms to provide information to producers with larger operations; and use popular press outlets and mailing of educational materials (for self-study) to serve his/her farmer clientele with smaller operations.

Willingness to Pay for a Potential Trout Aquaculture Insurance Policy

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An essential part of developing an insurance policy is estimating premium rates and drafting policy language. However, market analysis of a potential insurance product is seldom well developed and often fails to answer the fundamental question, "Are potential buyers willing and able to pay the required premium?" In this paper, we assess whether or not demand for a hypothetical trout aquaculture insurance product exists. In other words, if the rate insurers charge for policies exceeds the rate producers are willing to pay, then no market will arise. Measuring willingness to pay (WTP) is challenging in the sense that, unless a pilot program is in place to determine interest in a product, the question is hypothetical. Obviously, WTP is a function of policy-specific attributes and producer and farm characteristics such as risk aversion and the ability to manage risk with other mechanisms. We use the contingent valuation method that involves asking individuals about their WTP for policies with various features.

We elicit the probability distribution of the WTP for two coverage levels and four premium rates associated with a policy insuring against death loss due to certain insurable diseases and other causes of loss. We use a variant of the one-and-one-half bounded model. If the producer is willing to pay for a pre-specified coverage level-premium rate combination and answers in the affirmative, there is no follow-up question. The probability is modeled as $\Pr\left(WTP \geq P_j\right)$. If the producer answers negatively, then the follow-up question asks the producer if he or she is willing to pay any positive amount for the insurance. If the producer answers negatively then the producer's WTP would go below the stated price range. The probability of the answers to the follow up question is modeled as. $\Pr\left(-\infty \leq WTP \leq P_j\right)$.

We contracted with the National Agricultural Statistics Service to survey a representative sample of trout producers. NASS conducted the survey from July 1, 2005, through August 12, 2005, in 20 trout-producing states. A total of 330 for-profit trout aquaculture producers were surveyed after excluding non-profit operations and producers with atypical production systems. Of the 330 trout producers, 268 actually completed the survey instrument, resulting in a response rate of 81 percent.

Empirical results of the WTP model indicate a positive and statistically significant wealth variable. This positive sign indicates producers with greater wealth are willing to pay higher rates. We find previous purchase of liability insurance and insurance coverage level both has statistically insignificant signs contrary to expectations. The more total pounds of trout a farm produces are also associated with a willingness to pay a higher rate. Producers who sell their trout primarily for recreational purposes (i.e., stocking) are willing to pay a higher rate than producers who primarily sell their trout for food. The signs on the location dummy variables indicate producers from North Carolina are willing to pay higher rates than producers in the West region, but producers in both areas are willing to pay more relative to producers in the Central region.

Empirically Evaluating the Flexibility of the Johnson Family of Distributions for Crop Yield Modeling: A Crop Insurance Application

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Introduction

Recently, Ramirez and McDonald (2006a) introduced an expanded form of the Johnson family of distributions, which includes the S_U, S_B, and the S_L (or log-normal) distributions, as another alternative parametric approach for modeling crop yields. They argue that, because the expanded Johnson family can accommodate all mean-variance-skewness-kurtosis (MVSK) combinations that may be theoretically exhibited by a random variable, the Johnson family should provide a reasonably accurate modeling of any parametric probability distribution that may be used to represent crop yields in practice. Thus, this would address the main disadvantage of parametric models cited in the literature (i.e. the lack of flexibility and the associated specification error risk) and also provide for a family of parametric distributions that can reasonably represent any parametric distribution that may truly underlie crop yields.

However, the flexibility of the Johnson family of distributions has not been empirically examined and its economic impact in terms of accurately setting crop insurance premium rates has not been investigated. Therefore, the main objective of this paper is to examine the flexibility of the Johnson family of distributions by assessing its statistical and economic performance in modeling crop yields when, in fact, the true underlying distribution is something else (i.e. a beta or a normal). The results of this study have important implications for modeling crop yields in risk analysis and crop insurance premium rate setting. This study also contributes to the literature by being one of the few studies that uses a crop insurance application to quantify the economic effects of using alternative parametric distributions to model crop yields.

Data and Research Methodology

The data used in this study are from the University of Illinois Endowment Farms. The managers of the Endowment Farms control over 11,000 acres distributed among farms ranging from 40 acres to 1,200 acres. Crop yield data from 1959-2003 are available for the 26 Endowment Farms, with sample size varying from 20 observations to 45 observations.

Using this data, we first parametrically fit the Johnson family (the S_U, S_B, and S_L), the beta, and the normal distribution to the yield-series of each of the 26 farms. The best fitting model is then determined by assessing the maximum log-likelihood values and utilizing likelihood ratio tests. Eight farms for which the best-fitting model is S_U, S_B, beta, and normal (two farms for each distribution) were then chosen as basis for the flexibility evaluation. To operationalize the flexibility evaluation, we assume that the best-fitting distribution for each of the selected farms is in fact the true underlying data-generating process (DGP). Then we used simulation procedures to generate a number of datasets per farm where we know the true underlying DGP. This allows us to assess how flexible the Johnson family is. For example, we could determine whether or not the S_U or S_B can closely approximate the actual skewness-kurtosis estimate even if the true data generating process is, say, beta. Actuarially fair premium rates (AFPs) for an Actual Production History (APH) insurance plan are then calculated to evaluate the economic flexibility of the Johnson family – i.e. how far off is the calculated AFP when the yield distribution is assumed to be S_B but the actual data-generating process is, say, beta?

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Summary of Results and Implications

Our results suggest that the S_B distribution, in particular, is a fairly flexible distribution because it can accurately represent the pdf of crop yields even if the true underlying distribution is beta or normal. Furthermore, average AFPs over 20 farm-level datasets calculated based on the S_U and S_B distributions are fairly accurate even if the true distribution underlying these 20 farms are not S_U and S_B (e.g. beta and/or normal). This result implies that if an average premium rate is needed for a certain geographic area, the Johnson family can reliably estimate this premium provided that there are a sufficient number of farms to average across. This may have profound implications in rating a previously uninsured crop where there are limited data per farm but there are a large number of farms to average over.

For example, assume that there are at least 20 farms of a previously uninsured crop in a county. If one wants to estimate an average AFP for this county, then our results suggest that using the Johnson family (S_U and S_B) to fit a distribution for each farm in the county and calculating an average AFP over these farms will probably produce an AFP estimate that is close to when the true DGP is used to calculate the AFP. The average AFP for the county can then be used as a basis for an Actual Production History (APH) crop insurance program (much like how the reference rate is used now in the current APH rating system). An individual risk classification system together with the average AFP calculated using the Johnson family can be used to generate individual rates.

References:

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An Internet-Based Tool for Weather Risk Management

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This paper addresses further the issue of insuring specific event risks in agriculture through heat and precipitation weather insurance. The paper introduces an internet based tool at www.weatherwizard.us that can access data from any weather station in the United States for which NOAA temperature and precipitation data is available. The program is designed for easy access by academic researchers and insurance practitioners with an interest in weather insurance and specific event risks.

The philosophy of the program is to take the work out of computing specific event risks so that more focus can be placed on outcome based management. The program can use daily high, average and low temperatures as well as precipitation. Numerous types of insurance products can be assessed by days in year and choice of years. These include precipitation insurance based on daily rain or cumulative rain over a period of time. Heat insurance can be assessed using daily temperatures as well as degree-day contracts. Degree-day contracts can be evaluated using either the burn-rate approach or the derivatives approach. In addition the program can compute the premiums for lump sum binary payments and option-type payoffs.

Results can be saved to an Excel file for further analyses and graphing. Such analyses include not only the comparison of specific event weather events and insurance but also differences across stations for the investigation of basis risk and regional differences.

The program is publicly available at www.weatherwizard.us.