Demand for Optional Units in Crop Insurance

by

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This article demonstrates the importance of temporal-spatial yield, acreage and price risk apart from price in addressing the importance of optional unit provision in Federal crop insurance program. Specifically, based on 1998 U.S. cotton producers data, the demand for optional versus basic unit is examined using binomial logit model.

Keywords: Demand, Spatial and Temporal Yield, Acreage and Price risk, Optional units, and Federal Crop Insurance

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Demand for Optional Units in Crop Insurance

The Federal Crop Insurance Corporation (FCIC) of the Risk Management Agency (RMA) under USDA in the early 1980's initiated the optional unit policy for purchasers of multiple peril crop insurance. Under the optional unit provisions, producers who farms satisfy certain spatial requirements are allowed to divided their farm into different insurable units and to report yields separately over the last 4-10 years on each unit. The optional unit[1] provision is popular with producers due to its low relative cost and the ability to indemnify losses on separate sections of land. Even without optional units, traditional revenue or yield-based insurance is faced with the issue of asymmetry of information between the producers and insurer within the RMA's insured pool.

Current research in the area of crop insurance revolves around moral hazard (Chambers, 1989; Just and Calvin, 1993; Coble et al, 1997), adverse selection (Quiggin et al, 1994; Just and Calvin, 1995; Atwood, Shaik, and Watts, 2001), rating methodologies, and demand for crop insurance (participation versus nonparticipation), crop insurance products (yield versus revenue) or crop insurance coverage (catastrophic versus 50% to 85% buyup). However, given the importance and attention received by optional unit provision (reports by USDA Office of the Inspector General in 1994 and 1999; and the U. S. General Accounting Office in 1999) in Federal crop insurance, we attempt to estimate the demand for optional units in crop insurance with available[2] RMA database.

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[1] Subdivision of the farm into optional units is allowed for land in different sections under rectangular survey, and for irrigated versus dryland production. A section is one square mile (or 640 acres) and where legal descriptions are not based on rectangular survey, alternative criteria such as Farm Agency Service farm serial number and non-contiguity are used to define insurable units.

[2] Information on wealth, risk aversion and the required socio-economic variables are seldom available in RMA databases.

Researchers have estimated the demand for crop insurance with yield risk along with price as the basis of the analysis. For estimating the demand for yield and revenue crop insurance, it is appropriate to include yield and price risk along with price. To estimate the demand for optional versus basic units within a farm, it is not only appropriate but necessary to include temporal and spatial yield, acreage and price risk along with price. Given the ability to insure multiple basic or optional units by a producer, it is imperative to account for temporal yield risk (variance) over time as well spatial yield risk across units. Similarly, it is important to account for the temporal and spatial acreage risk. Inclusion of temporal and spatial price risk along with price would allow us to examine the demand with variation in prices across units and over time.

The demand of optional units is examined by the comparing the expected utility of producer with and without optional units using a multinomial logit model with producers characteristics data. The vector of exogenous choice specific variables included the returns to insurance – first and second moment of yield, acreage and price risk across units. The second moment of yield, acreage and price risk is dis-aggregated into spatial variance and temporal variance (see Shaik and Atwood, 2002). Price is defined as the yield based multiple peril crop insurance premium rates. The individual characteristics data include insurance product (yield and revenue), coverage type (catastrophic and buyup), coverage level (percent of election 50% to 75%), practice (irrigated versus dryland), and farm size. We conduct the analysis for all the major cotton growing states in U.S. using farm-level data sets from Risk Management Agency. Sub-analysis is conducted for only those farms with more than 640 acres.

II. Model of Asymmetric Information

In this section, we develop an asymmetric information model for crop insurance

optional unit provision incorporating the spatial and temporal yield, acreage and price risk to examine the demand for optional units. Consider a stylized[3] producer assumed to maximize expected utility according to the von Neuman-Morgenstern utility function defined over wealth (W). With the optional unit provision, the stylized producer compares expected utility of an optional unit farm $EU_{OU}(W)$ to the expected utility of a basic unit farm $EU_{BU}(W)$. Although the distribution of the individual producer's EU evaluation of wealth under each alternative is unknown, the objective measures of farm risk can be obtained for exogenous factors that influence the decision[4] to insure as a multiple-unit farm.

The model of expected utility for the two alternatives is written as:

$$(1)\quad \begin{aligned} EU_{OU} &= \beta_{OU}{}' X + \varepsilon_{OU} \\ EU_{BU} &= \beta_{BU}{}' X + \varepsilon_{BU} \end{aligned}$$

The terms β_{OU} and β_{BU} are vectors of coefficients of exogenous variables **X** to be estimated with ε_{OU} and ε_{BU} representing the error terms.

The difference in expected utility is:

$$\begin{aligned} (2)\quad EU_{OU} - EU_{BU} &= \beta_{OU}{}' X + \varepsilon_{OU} - (\beta_{BU}{}' X + \varepsilon_{BU}) \\ &= (\beta_{OU} - \beta_{BU})' X + (\varepsilon_{OU} - \varepsilon_{BU}) \\ &= \beta' X + \xi \end{aligned}$$

The decision to insure as optional-unit farm reveals that $EU_{OU} - EU_{BU} > 0$ and if a farmer chooses to insure as a basic-unit farm, then $EU_{OU} - EU_{BU} < 0$.

For stylized producers, the decision $\tilde{\Omega}$ to insure as optional-unit farm over a basic-

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[3] By stylized producer, we mean a risk-averse producer following the von Neuman-Morgenstern utility function.

[4] Here we are modeling the number of optional or basic units insured within a farm as a choice rather then a decision, basically, to examine the demand of optional unit policy. However, the choice of the producer to insure more than one unit within a farm has to be examined only for farms with more than 640 acres.

unit farm depends on the expected return to insurance as reflected in the farm yield risk (differentiated into temporal risk, σ_y^t and spatial risk, σ_y^s); individual farm productivity, μ; farm acreage risk (differentiated into temporal risk, σ_a^t and spatial risk, σ_a^s); acreage, A; farm yield risk (differentiated into temporal risk, σ_p^t and spatial risk, σ_p^s); price, p; and control variables like insurance type, ω^I; coverage, ω^C; coverage, ω^C; number of basic or optional unit insured within a farm policy number, ω^U; and number of actual reported yields, ω^A:

$$(3) \quad \tilde{\Omega}(\sigma_y^t, \sigma_y^s, \sigma_a^t, \sigma_a^s, \sigma_p^t, \sigma_p^s, \mu, p, A, \omega^I, \omega^C, \omega^U, \omega^A)$$

The variables of equation (3) embodied in vector **X** of equation (3) influencing the expected utility to insure an optional-unit farm over a basic-unit farm ratio is examined by estimating a discrete choice logit model. The discrete choice binomial logit model is employed to estimate the demand expressing an individual producer's choice to insure basic versus optional units within a farm as a function of yield, price and acreage risk differentiated into temporal and spatial, individual farm productivity, price, acreage, control variables that includes type of insurance, insurance coverage, and actual yields reported; along with practice and state dummy variables.

III. Procedures

An application of the producer decision to insure as a optional-unit farm is modeled for all U.S. producers who purchased cotton insurance for the year 1998 using RMA's yield database. The producers were restricted to those who purchased additional coverage i.e., buyup policies. To estimate the demand for optional-unit farm versus the basic-unit farm, binomial logit model is estimated with the choice of type of unit insured as the dependent variable. The dependent variable is coded 0 for basic-unit farm and 1 for optional-unit farm. The discrete choice binomial logit model:

$$(4)\ \text{Optional Unit Farm} = \alpha_0 + \alpha_y^t\, Temporal\ Yield\ Risk + \alpha_y^s\, Spatial\ Yield\ Risk + \mu\, Farm\ Productivity + \alpha_a^t\, Temporal\ Acreage\ Risk + \alpha_a^s\, Spatial\ Acreage\ Risk + A\ \ Acreage + \alpha_p^t\, Temporal\ Price\ Risk + \alpha_p^s\, Spatial\ Price\ Risk + p\ Price + \omega^C\, Coverage + \omega^A\, Actual\ Yields\ + \omega^U\, Number\ of\ Units + \beta_0\, D\_prac + \varepsilon$$

Information on each producer who purchased cotton insurance for the year 1998 was extracted from RMA's yield history data file[5]. Information on the basic and optional unit within a farm, yield and revenue insurance, coverage level, number of basic or optional units insured within a farm policy, and the number of actual yields reported by the producer is identified and extracted from the yield history data.

In the yield history file, each producer at the time of purchasing insurance is required to submit verified yield and acreage data for the last 6-10 years of actual data. These 6-10 years of unit level yield information within a farm represents the cross-sectional time-series data. Each producer's farm yield, acreage and price risk is decomposed into temporal and spatial risks utilizing the two-way random effects panel model error decomposition (see Shaik and Atwood, 2002 for details). Price is defined as yield based premium rate at 50 percent coverage. Information on other exogenous variables available in the yield history file is obtained as well to be used in the analysis.

The independent variables along with the second, third and fourth moment of yield, acreage and price are defined in Table 1. The number of insured cotton farms and the arithmetic mean of variables used in the analysis by basic unit farm and optional-unit farm are presented in Table 2. The number of farms is almost equally distributed between basic unit (164453) and optional unit (15736) farms. The average yield was lower for optional unit farms relative to basic unit farms. While the temporal and spatial risk was higher for optional

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[5] Risk Management Agency's database consists of a number of different databases containing information with respect to insurance companies, agents, adjusters, and producers. RMA's yield history data set contains producers' reported historical yields used in establishing an average or "approved" yield at the beginning of the insurance year. RMA's loss history data set collects indemnities paid at the end of the insurance year.

unit farms. With acreage variable, the total acreage, temporal and spatial risk was lower for basic unit farms. However the premium rate for basic unit is relatively higher than optional unit farms, however the spatial price risk is very high for optional unit farms.

IV. Results

To examine the demand for optional unit policy, binomial logit model was estimated using all cotton producers in U.S. for the year 1998 using SAS 9.0. The regression results of discrete choice models along with the goodness of fit measures are presented in Table 3. As expected the farm productivity was negative and significant indicating with higher yields producer tend to insure as basic unit farms. However, increased variation across units (over time) within a farm producers tend to insure as optional (basic) unit farms. Producers with higher farm size and increased temporal acreage variation tend to insure as optional unit farms. With increase in price, producers tend to insure as basic unit farms.

The conditional variables, insurance type and coverage did not exhibit the expected results. Producers with revenue insurance tend to insure as basic unit farms and at higher coverage. Irrigated producers tend to insure as basic unit farms. With more number of units within a farm and less number of actual yields reported, producers tend to insure as optional unit farms.

The significance on yield, acreage and price risk is an indication of the presence of adverse selection between basic and optional unit farms in RMA pools of cotton producers for the year 1998.

The marginal effects as well as the elasticities for the exogenous variables used in the discrete choice model are reported in Table 3. The variable of interest, the price seems to report a -0.14 marginal effect and -0.054 elasticity.

V. Conclusions

Using a two-way random effects panel model, we develop measures of temporal and spatial yield, acreage and price risk variables along with price to examine the demand for optional unit provision. These preliminary results reported needs to be further refined.

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Table 1. Definitions of Variables used in the Analysis

Variable	Units	Definitions
Unit Type	Number code	Basic unit, Optional unit is coded as 0, and 1 respectively
Temporal Yield Risk	Pounds	Yield variation over time
Spatial Yield Risk	Pounds	Yield variation across units
Farm Productivity	Pounds	Arthimetic mean of yield
Temporal Acreage Risk	Pounds	Acreage variation over time
Spatial Acreage Risk	Pounds	Acreage variation across units
Acreage	Acres	Total acreage under crop insurance
Temporal Price Risk	Pounds	Price variation over time
Spatial Price Risk	Pounds	Price variation across units
Price	Dollars	Yield based premiums rates published by RMA
Insurance Type	Number code	Yield and Revenue based crop insurance is coded as 0 and 1 respectively
Coverage	Number code	The 50%, 55%, 60%, 65%, 70% and 75% coverage are coded as 0, 1, 2, 3, 4, and 5 respectively
Number of Units	Number	Number of units insured within a farm policy
Number of Actuals	Number code	If the number of actual yields reported are < 4 is coded as 0 and 1 if >4 number of actual yields reported
Moment of Yield, Acreage and Price		
Second	pounds	Standard deviation, a measure of how widely values are dispersed from the mean
Third		Skewness, a measure of symmetry relative to a normal distribution
Four		Kurtosis, a measure of whether the data are peaked or flat relative to a normal distribution.

Table 2. Arithmetic Mean of Variables used in the Analysis by Basic and Optional Unit Farms

Variables	Basic Unit		Optional Unit	
	Mean	Std	Mean	Std
Number of Farms	16,453		15,736	
Temporal Yield Risk	178.5	98.4	161.0	92.4
Spatial Yield Risk	8.5	27.8	41.3	62.0
Farm Productivity	421.8	239.0	465.1	249.0
Temporal Acreage	23.8	108.8	38.9	81.2
Spatial Acreage Risk	7.4	36.3	25.4	60.8
Acreage	153.1	184.8	371.8	1911.6
Temporal Price Risk	0.057	0.037	0.046	0.036
Spatial Price Risk	0.003	0.009	0.010	0.016
Price	0.199	0.109	0.180	0.103
Insurance Type	1.016	0.125	1.015	0.121
Coverage	2.095	1.375	1.858	1.442
Number of Units	0.321	0.898	1.844	2.351
Number of Actuals	0.875	0.331	0.713	0.452
Irrigated Dummy	0.716	0.451	0.560	0.496
Moments of Yield, Acreage and Price				
Yield deviation	204.2	102.5	202.8	95.1
Yield Skewness	-0.160	0.843	-0.160	0.841
Yield Kurtosis	0.075	1.708	0.207	1.659
Acreage deviation	26.4	98.9	45.1	84.5
Acreage Skewness	0.105	1.129	0.137	1.035
Acreage Kurtosis	0.728	2.489	0.648	2.290
Price deviation	0.065	0.040	0.057	0.041
Price Skewness	0.718	1.198	0.849	1.112
Price Kurtosis	0.799	3.162	1.137	3.012

Table 3. Regression Results from Binomial Logit Analysis of Optional Unit Provision Using U.S. Cotton Data, 1998

Parameters	Parameter Estimates	Probability	Marginal Effect	Elasticity Esimates
Intercept	0.76868	0.0000		
Temporal Yield Risk	-0.00194	0.0000	-0.00060	-0.203
Residual Yield Risk	0.00224	0.0000	0.00070	0.024
Farm Productivity	-0.00015	0.0092	-0.00005	-0.040
Temporal AcreageRisk	0.00067	0.0000	0.00021	0.014
Residual Acreage Risk	-0.00150	0.0000	-0.00047	-0.013
Acreage	0.00036	0.0000	0.00011	0.045
Temporal Price Risk	1.85328	0.0000	0.57627	0.061
Residual Price Risk	6.34883	0.0000	1.97415	0.020
Price	-0.45279	0.0017	-0.14079	-0.054
Insurance Type	-0.20379	0.0011	-0.06337	-0.127
Coverage	-0.04471	0.0000	-0.01390	-0.054
Number of Units	0.33936	0.0000	0.10552	0.356
Number of Actuals	-0.49200	0.0000	-0.15299	-0.246
Practice (Irrigated=1)	-0.80817	0.0000	-0.25130	-0.304

Goodness of Fit Values	
Aldrich-Nelson	0.231
Cragg-Uhler 1	0.2595
Cragg-Uhler 2	0.3461
Estrella	0.2873
Adjusted Estrella	0.2864
McFadden's LRI	0.2168
Veall-Zimmermann	0.3978
McKelvey-Zavoina	0.6274