The Demand for Specialty-Crop Insurance:

Adverse Selection and Moral Hazard[*]

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Abstract:

The twin problems of moral hazard and adverse selection are often blamed for the lack of an active crop insurance market for fruits and vegetables. This paper develops an alternative method of estimating the demand for insurance that uses a contingent valuation approach. Technical inefficiency is interpreted as an indicator of a moral hazard effect. The results support the existence of moral hazard.

Introduction

Moral hazard is often offered as an explanation for both low participation rates and high loss-ratios (the ratio of indemnities to premiums) in agricultural crop insurance (Ahsan, Ali, and Kurian; Nelson and Loehman; Chambers; Smith and Goodwin). However, there are many definitions of moral hazard in the theoretical literature, and still more employed in empirical studies of the demand for insurance. Arrow, for one, suggests a simple and compelling definition of moral hazard as "hidden action" on the part of an insured agent. With the multiplicity of definitions of moral hazard comes as many alternative methods of measuring or detecting its presence in insurance markets.

Recent attempts include Quiggin, Karagiannis, and Stanton (QKS) who estimate a Cobb-Douglas production function and input share system with a binary variable indicating insurance participation. With this framework, they conclude that moral hazard exists if the coefficient on the insurance dummy is negative in both output and chemical equations. Alternatively, Just and Calvin (JC) use a mean-variance expected utility model to motivate two simple measures of moral hazard and adverse selection. Moral hazard, they claim, must exist if realized yields fall below the producer's subjective expectations. Furthermore, they interpret a deviation between Federal Crop Insurance Corporation (FCIC) and expected yields as evidence of adverse selection. Others claim that the use (or nonuse) of risk reducing inputs indicates the presence of moral hazard (Horowitz and Lichtenberg). However, such a clear relationship between observable output or input levels and the decision to insure must surely be evidence of violating the "best practice" condition of any insurance contract. Therefore, evidence of moral hazard must be found in otherwise unobservable

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measures of performance.

The deviation of a producer from his or her potential level of output, Farrell's definition of inefficiency, provides one such measure. Many empirical applications of this notion of inefficiency exist in agricultural economics, including Bravo-Ureta and Rieger in dairy, and Akridge and Hertel in agricultural supply cooperatives, among others.[1] These applications involve the estimation or construction of a stochastic production frontier where the random error about the maximum level of output for a given bundle of inputs includes deviation resulting both from truly random factors and a measure of idiosyncratic inefficiency. However, this approach presumes that the producer's objective is to achieve a maximum level of output using this bundle of inputs. However, when producers use inputs to both increase output and to lower the variance of output (Just and Pope), then it is more plausible to define their objective in terms of both the mean and the variance of output. In this context, efficiency is achieving the optimal tradeoff between risk and return. If the presence of insurance causes a producer to deviate from this optimal tradeoff, then this provides more conclusive evidence of moral hazard.

The existence of moral hazard and, to a lesser extent adverse selection, in specialty crop insurance mean that insurance markets either do not exist, or are extremely thin (Lee, Harwood, and Somwaru). Many of the major fruit and vegetable crops were only brought into the FCIC fold by the 1980 Federal Crop Insurance Act, and still suffer from poor participation rates.[2] Because of the absence of insurance markets, price and quantity data that are usually used to

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[1] Much of this literature prior to 1992 is reviewed by Battese.

[2] This list includes almonds, cranberries, grapes, onions, peppers, popcorn, and walnuts, or "...any agricultural commodity grown in the United States (Gardner and Kramer). Insurance for potatoes, tomatoes, peaches and citrus was available prior to the Act.

estimate the demand for insurance do not exist (Barnett, Skees, and Hourigan; Hojjati and

Bockstael; Calvin; Goodwin, Coble et al.). However, the fact that many growers have an interest

in fruit and vegetable insurance suggests this is not due to a lack of demand, but a lack of a

mechanism to achieve a market equilibrium (Blank and MacDonald). In the absence of an active

market, contingent valuation (CV) methods have proven valuable in eliciting potential

participants' willingness to pay for a good or amenity (McFadden). This study employs a CV

approach in estimating the potential demand for specialty-crop insurance.

The objective of this paper is to develop an empirical test for moral hazard that uses the

definition of inefficiency ventured above. The first section presents an alternative objective

function for an agricultural producer that considers both the level and the variance of output.

Next, the paper presents a definition of inefficiency that uses this risk and return objective

function. The stochastic production function method is then extended to include this new

definition of inefficiency and moral hazard. Finally, an empirical example of the demand for

insurance among U.S. fruit and vegetable growers both demonstrates the value of a CV approach

to insurance valuation and tests several hypotheses of the determinants of insurance demand.

A Model of Production with Moral Hazard and Adverse Selection

Suppose that growers face a production technology similar to QKS where output is a function of

a vector of variable inputs (X), fixed inputs (Z), grower effort (θ), and an additive error term that

$$Y \ = \ f(x, z, \theta) \ + \ \varepsilon \ \text{ where } \ \varepsilon \ = \ (v, \mu).$$

allows for both the random influences of the environment (v), and managerial skill (μ):

In their model, QKS interpret the unobservable effort variable, θ, as a indicator of moral hazard, whereas including a random "managerial skill" component to their multiplicative error term represents the effect of adverse selection on output. Although QKS define *x* as consisting of only risk-increasing inputs, a more general definition, such as in the production function of Just and Pope, allows *x* to contain both risk-increasing and risk-decreasing inputs.

$$\pi = pf(x,z,\theta) + \varepsilon - wx - rz = \bar{\pi} + \varepsilon;$$

With the technology shown in (1), producer income becomes:

Where *w* is the vector of variable input prices, and *r* is the vector of rental prices on the quasi-fixed inputs. When deciding whether or not to insure their crops in a risky environment, however, risk averse producers consider the expected utility of profit rather than simply the amount of profit.

To determine the amount producers are willing to pay for insurance, begin by expanding

$$U(\pi) \cong U(\bar{\pi}) + \varepsilon U'(\bar{\pi}) + \frac{\varepsilon^2}{2}U''(\bar{\pi}) + r_3\varepsilon$$

the general expression for the utility of income about the mean of income:

Where the higher order terms go to zero with ε. Given the expression for income in (3), the expected utility of profit is written as:

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$$E[U(\tilde{\pi})] = U(\overline{\pi}) + (1/2)\int_{\varepsilon_L}^{\varepsilon_H} \varepsilon^2 \phi(\alpha)\,d\alpha U''(\overline{\pi}) + E[r_3\varepsilon],$$

Where ϕ is the density function of a the random error term. In order to determine the "price of risk", Stiglitz and Newbery (1984) compare the mean level of income to its certainty equivalent, or the certain level of income that generates a utility level equal to the expected utility of a random income: $E[U(\tilde{\pi})] = U(\hat{\pi})$. Using this result, the price of risk is then the difference between the mean and certainty equivalent levels of income: $\rho = \overline{\pi} - \hat{\pi}$. Expanding the utility of the certainty equivalent income gives an expression in terms of the mean income and the price of

$$U(\hat{\pi}) = U(\overline{\pi} - \rho) \cong U(\overline{\pi}) - \rho U'(\overline{\pi}) + r_2(\rho),$$

risk:

where again the higher order remainder terms go to zero with the price of risk. Setting (5) equal

$$\rho = -(1/2)\left(\frac{var(\varepsilon)U''(\overline{\pi})}{U'(\overline{\pi})}\right),$$

to (4) and solving for the price of risk gives:

Several conclusions follow from this result. Most important, under the assumption of decreasing absolute risk aversion (DARA), an increase in the variance of output, and, hence income, causes the price of risk to rise. Therefore, production inputs that cause the variance of output to rise are likely to cause the willingness to pay for insurance to rise, while risk-reducing inputs reduce the willingness to pay for insurance. Ramaswami (1993) provides a similar result in

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a multi-input model that takes into account both the output and risk effects of additional input use. To the extent that θ measures unobservable producer decisions, a lower value of θ reduces the level of income. With the DARA assumption, this means that lower θ values result in a higher willingness-to-pay for insurance, ceteris paribus. This result also suggests that more specific assumptions about the distribution of ε can provide insight as to the potential factors that influence the willingness-to-pay for insurance. Furthermore, if two producers are identical in every other observable respect, a difference in willingness-to-pay that is caused by factors within the distribution of ε can suggest an alternative indicator of adverse selection in crop insurance.[3]

Specifically, assume that the random error term, ε, is composed of the two elements suggested in (1) above in the following form: $\varepsilon = v - |u|$. With this definition, the effect of climate on output is a random normal variable: $v \sim N(0, \sigma^2_v)$, and managerial quality, or the proxy

$$g(u) = \frac{2}{\sigma_u 2 \pi^{1/2}} \exp\left(-\frac{u^2}{2\sigma_u^2}\right) \quad (u > 0)$$

for the effect of adverse selection (u) follows a half-normal distribution:

so that the function f above describes a stochastic production frontier. Because this technology defines a frontier along which only the most efficient producers lie, the greater the individual realization of u, the greater is the deviation from the best practice frontier. Assuming that v and u

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[3] Despite many authors' arguments to the contrary, as QKS suggest the difference between moral hazard (MH) and adverse selection (AS) in agricultural crop insurance is unobservable as the decisions to insure and to plant are made simultaneously. Attempts to differentiate between the two largely rest on semantic arguments as to the timing of each decision. For our purposes, AS is interpreted as flowing from hidden information about inherent producer characteristics, while MH results from specific input decisions unknown to the insurer.

are independently distributed, the standard deviation of the composed error term is:

$\sigma = (\sigma_v^2 + \sigma_u^2)^{(1/2)}.$ Clearly, the greater the deviation from the frontier, the greater the

variance of total production.   Therefore, combining this result with (6) above shows that a higher

level of inefficiency leads to a greater willingness-to-pay for insurance.

While this result allows for predictions of aggregate effects, detecting individual cases of

adverse selection requires a firm-specific measure of inefficiency. Jondrow, Lovell, Materov, and

Schmidt (1982) derive such a measure from the expectation of u, conditional on each firms'

realization of ε. In the composite normal/half normal case described above, the expected value of

$$E(u/\varepsilon_i) = \varepsilon_i\left(-\sigma_u^2\right) + \frac{\sigma_u^2 \sigma_v^2}{\sigma}f\left(\varepsilon\sigma_u\right)\left(1 - F\left(\varepsilon\sigma_u\right)\right)^{-1}$$

u for each farm is written:

where f is the normal density function, and F is the normal distribution function. Subtracting the

expectation of u from the residual ε_i gives the value of the random component of the deviation

from the best-practice frontier: v_i. Subtracting this random deviation from the predicted level of

output and dividing the result by the actual level of output yields an index of efficiency for each

observation.

This vector of efficiency indices allow the econometric estimation of the factors that

contribute to the willingness-to-pay for insurance according to the theoretical model of equation

(6). Namely, the willingness-to-pay is a function of the variation in output, an index of technical

efficiency, various indicators of growers' attitudes towards risk, and their tendency to self insure

through diversification or other means. As in JC, proxy variables for these factors include such

socioeconomic factors as the level of off-farm income, the capital structure of the farm, the

producer's age, her level of education, cooperative membership, the level of crop and geographic

diversification of the farm, or the use of irrigation. Goodwin provides a discussion of how each of

these factors is expected to influence the demand for insurance. Parameter estimates that show a

higher willingness-to-pay for the more inefficient producers suggests moral hazard may present a

problem for fruit and vegetable insurance, while a positive effect of historical yield variability may

indicate the presence of adverse selection in the sense of QKS.[4]   Including yield variation in the

set of explanatory variables captures growers' dual objective of achieving maximum return

conditional on a level of returns variability. Measures of yield risk and the subjective value of

insurance are described in the following section.

Data and Methods

A nationwide survey of fruit and vegetable growers provides the data for this study. Specifically,

a cluster-sample was defined for each of 32 commodities, both insurable and non-insurable, with a

target response of at least twenty growers per commodity. The number of growers per state was

selected on a grower-number basis, and not by production value. With a focus on explaining

likely aggregate participation rates, sampling by population rather than value of production

provides a better indication of the likely distribution of insurance buyers. The sub-sample selected

for this study include potato, apple, grape, onion, and watermelon growers. Of the total 132

responses, 67 provided useable input and yield data. The survey was mailed in December, 1995

and the responses used in this study collected by April 30, 1996. Data pertain to the 1995 crop

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[4] Where FCIC insurance is not available, some producers still are able to purchase private insurance.
Participation in the recently introduced NAP also indicates a proclivity to insure.

year.

The survey instrument consists of three parts: demographic and farm type questions, crop production and input values, and the value of various insurance alternatives. The farm-attribute questions ask whether the grower contracts his or her production, whether the grower belongs to a cooperative, the degree of vertical integration, crop insurance purchase history, percentage of family income earned off-farm, the farm's debt-to-assets ratio, the grower's age, and his or her level of education. The crop production section provides information on the number of crops grown, acreage of the primary crop, the distance between parcels of that crop in miles, a five-year history of irrigated and non-irrigated acreage and yields, the average price per pound of 1995 output, and value of fertilizer, chemicals, labor, water, seed, fuels, and other variable costs used in 1995. This section also asks growers to rank the importance of yield, output price, labor cost, and input cost risk on a Likert scale (1 = high risk, 5 = low risk).

The third section of the survey asks growers to place a subjective value on several insurance alternatives. This study concerns variants of one - the cost of production insurance option. Growers are asked to submit what they would be willing to pay, on a per acre basis, for insurance that guarantees them 100% of their variable costs of production if their yield falls below 65%, 75%, or 85% of their historical average yield. Approximately 30% of the sample growers, however, would not consider insurance, so entered a "zero" willingness to pay for all options.

Because of the number of null responses, the distribution of the willingness to pay for insurance is assumed to be truncated at zero. Therefore, the empirical insurance demand model uses a Tobit estimation procedure (Maddala). A Tobit approach is required if growers reveal a positive willingness to pay ($W > 0$) only if the latent, or unobserved willingness to pay

($W^* = \alpha + \beta' X_i + \varepsilon^*$) exceeds a certain limit value - zero in this case. In order to pool

insurance valuations across commodities, the dependent variable (W_i) is expressed as a percentage

of the total cost of production per acre. Among the explanatory variables, yield variability is

measured as the five-year coefficient of variation, and the expected price is simply taken to be a

naive forecast - growers are assumed to expect last year's price to prevail next period. This

model is estimated using the maximum likelihood procedure in LIMDEP 7.0.

Results and Discussion

Table 1 provides parameter estimates that are defined as the marginal effect of a change in each

element of **X** on the expected, conditional willingness to pay. Estimates of the Cobb-Douglas

production frontier used to derive the farm-specific measure of efficiency are available from the

authors, so this section focuses on the insurance demand results. [table 1 in here]

Whether reflecting inherent managerial ability (adverse selection) or input choice once

the insurance decision is made (moral hazard), these results support the central hypothesis of the

paper that more efficient growers are willing to pay less for insurance. Table 1 also shows that

growers who contract their production are willing to pay more for each level of coverage,

suggesting that these growers are particularly risk averse. Similarly, older growers' greater

willingness to pay may indicate that they tend to be more risk averse than younger growers.

Although growers who are less concerned with yield risk appear to be willing to pay more for

insurance, suggesting that adverse selection may indeed present a problem for fruit and vegetable

insurance, the effect of historical yield variability on the willingness to pay for insurance is

statistically insignificant. Likewise, growers who expect a higher price for their produce are not

willing to pay more for insurance than others. Although two methods of providing self-insurance,

geographic and crop diversification, do not affect the willingness to pay, growers who irrigate do place a lower value on the ability to insure yields. Further, growers with a history of program participation and with a higher debt-to-assets ratio are willing to pay less for insurance. In the former case, this result supports the contention by some (Calvin and Just) that growers become dependent upon government support, so see little need for private insurance. In the latter case, growers with more debt may be inherently risk loving, or may have less resources to spend on insurance. In summary, including a measure of intrinsic managerial ability in model of insurance demand causes variables that have previously been shown to positively effect the demand for insurance to become insignificant, namely the expected price of output and the historical variability of farm yields (Coble, et al.).

Conclusions

Continual low participation rates in agricultural crop insurance are typically blamed on moral hazard and adverse selection problems. Existing empirical measures of moral hazard and adverse selection in crop insurance consider lower yields by insured producers, or large deviations between expected and actual yields as evidence of their existence. This paper shows that producers' technical efficiency is an important determinant of their willingness to buy crop insurance. Specifically, a more inefficient producer is likely to have a higher willingness-to-pay for insurance for two reasons: first, a higher level of inefficiency causes the variance of output to rise, ceteris paribus, and second, a more inefficient grower is likely to find it more costly to reduce risk through his or her own behavior. Where markets for insurance either do not exist or are not widely used, a contingent valuation approach is required to examine the effect of inefficiency on the willingness to pay for insurance.

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Empirical results from a survey of US fruit and vegetable growers support the hypothesized effect for three levels of cost of production crop insurance coverage. Growers who are more efficient, have higher debt to assets ratios, have participated in crop programs in the past, and who use irrigation all place a lower value on crop insurance. On the other hand, older growers, growers who contract their output, or those who are less concerned about yield risk are willing to pay more for insurance. Taken together, these results suggest that the potential for adverse selection and moral hazard to arise in fruit and vegetable insurance is significant and can explain why such insurance is not widely used today.

Table 1. Tobit Model Estimates of Insurance Demand Equations: Cost of Production Options

Variable	65% Coverage		75% Coverage		85% Coverage	
	Estimates[2]	t-ratio	Estimate	t-ratio	Estimate	t-ratio
Constant[1]	-0.1425	-1.3920	-0.0163	-0.1090	-0.1110	-1.0660
Contract	0.0822*	2.6710	0.0612	1.3750	0.1049*	3.3240
History	0.0199	0.6760	-0.0463	-1.1210	0.0059	0.2000
Program	-0.0565*	-2.0290	-0.0661*	-1.6620	-0.0610*	-2.1790
Off farm Inc	-9.1275	-0.1240	0.4597	0.0040	1.8007	0.2290
Debt Ratio	-1.5334	-1.4860	-1.2232	-0.7920	-1.4384	-1.3080
Age	0.0389*	2.3950	0.0350	1.4780	0.0552*	3.3250
Education	-0.0126	-0.9190	-0.0272	-1.3600	-0.0262*	-1.8690
Num. Crops	8.5981	0.8830	1.3218	0.9040	1.3700	1.3140
Distance	0.2407	0.9490	-0.1362	-0.6630	-0.1132	-0.7720
Irrigation	-0.0479*	-1.6200	-0.0427	-1.0030	-0.0440	-1.4730
Risk Att.	0.0214*	1.7840	0.0227	1.2870	0.0152	1.2370
Efficiency	-0.0451	-1.3440	-0.0395*	-1.7860	-0.0270*	-1.7730
Yield Risk	-0.3895	-0.4220	0.4681	0.9500	0.4023	1.1480
E[P]	0.2103	0.1730	1.6730	1.0170	4.5461	0.4090
σ	0.0906*	9.0780	0.1363*	9.9060	0.0974*	10.6050
R[2]	33.8%		22.8%		34.7%	

[1] A single asterisk indicates significance at a 5% level. Variable definitions are provided in the text, while σ is the estimated variance. Note that the parameters have been scaled for presentation purposes: Off farm income by 10^8, debt ratio by 10^6, number of crops by 10^3, distance by 10^4, yield risk by 10^3, and E[P] by 10^6.

[2] The marginal effects of each explanatory variable on the willingness to pay is given by:

$$\partial E[y/x] \,/\, \partial x \;=\; \Phi(\,\beta'x \,/\, \sigma\,)\beta,$$

where Φ is the normal distribution function, y is the vector of willingness' to pay

and x is the matrix of explanatory variables.

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