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**A TWO STAGE MODEL OF THE DEMAND FOR
SPECIALTY CROP INSURANCE**

by:

Timothy J. Richards

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Dr. Timothy J. Richards

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A Two-Stage Model of the Demand for Specialty Crop Insurance

by

Timothy J. Richards*

* Author is an assistant professor in the Morrison School of Agribusiness and Resource Management, Arizona State University East, Mesa, AZ. 85206. The author is grateful to Richard Anderson of the Federal Crop Insurance Corporation for providing the data, but all findings and conclusions are those of the author and not the FCIC.

A Two-Stage Model of the Demand for Specialty Crop Insurance

Abstract

Proposals for reform of the federal multiple-peril crop insurance program for specialty crops seek to change fees for catastrophic (CAT) insurance from a nominal fifty-dollar per contract registration fee to an actuarially sound premium. Growers argue that this would cause a significant reduction in participation rates, thus impeding the program's goals of eventually obviating the need for *ad hoc* disaster payments and worsening the actuarial soundness of the program. The key policy issue is, therefore, empirical one - whether the demand for specialty crop insurance is elastic or inelastic. Previous studies of this issue using either grower or county-level field crop data typically treat the participation problem as either a discrete insure / don't insure decision or aggregate these decisions to a continuous participation rate problem. However, a grower's problem is more realistically cast as one of simultaneously making a coverage level / insurance participation decision. Because the issue at hand considers a significant price increase for only one coverage level (50%), differentiating between these decisions is necessary both from an analytical and econometric standpoint. To model this decision, the paper develops a two-stage estimation procedure based on Lee's multinomial logit-OLS selection framework. This method is applied to a county-level panel data set consisting of eleven years of the eleven largest grape-growing counties in California. Results show that growers choose among coverage levels based upon expected net premiums and the variance of these returns, as well as the first two moments of expected market returns. At the participation-level, the mean and variance of indemnities are also important, as are several variables measuring the extent of self-insurance, such as farm size, enterprise diversity, or farm income. The results also show that the elasticity of 50% coverage insurance is elastic, suggesting that premium increases may indeed worsen the actuarial soundness of the program. These increases will also cause a significant adjustment of growers among coverage levels.

keywords: California, crop insurance, discrete/continuous choice, grapes, multinomial logit.

A Two-Stage Model of the Demand for Specialty Crop Insurance

Introduction

Since the creation of “catastrophic” (CAT) multiple-peril crop insurance in the Federal Crop Insurance Reform Act (FCIRA) of 1994, many specialty crop growers have come to rely on this option as an inexpensive safety net in the event of a major crop failure. However, fruit and vegetable growers are now concerned that proposals to change the cost of CAT insurance from a flat, fully-subsidized fee to a more traditional actuarially determined premium would mean a dramatic rise in the premiums they must pay. Grower groups argue that these changes, intended to increase the financial viability of specialty crop insurance, will instead cause many growers to go without multiple-peril crop insurance (Jones) and thus exposed to significant losses in the event of a poor harvest. Whether these inevitable defections cause an overall deterioration of the financial viability of specialty crop insurance depends upon the elasticity of demand for insurance so is thus an empirical question (Goodwin 1993). In fact, if the demand for CAT insurance is price-elastic, then increasing premiums may actually worsen the actuarial soundness of the entire program if many “good risk” growers choose not to insure.

However, the implications of driving growers out of the federal crop insurance program go far beyond the financial soundness of the program itself. As a result of the FCIRA, participation in at least a catastrophic level of insurance is required for benefits from farm programs.¹ If this feature of the 1994 Act reflects an intention to have CAT ultimately replace *ad hoc* disaster payments, as is commonly believed, then growers without insurance, or who have not

¹ Catastrophic insurance provides growers a minimal level of coverage - 50% of insured yield at 60% of the expected market price. Premiums are a nominal registration fee, initially set at \$50 per contract and capped at \$200 per farm per county, or \$600 per farm in total.

self insured through geographic or product diversification or some other means, may be saddled with crippling losses. Inevitably, this will lead to calls for a resumption of relief, thus undermining *both* policy objectives of universality and actuarial soundness. With the movement towards limiting government spending in agriculture, there is a growing body of empirical research into the financial viability of crop insurance in general, and the demand for crop insurance in particular.

Typically, models of the demand for crop insurance that use farm-level data seek to explain a grower's decision of whether to insure (Calvin; Just and Calvin; Coble et al.) or the joint decisions of whether and how much to insure (Goodwin and Kastens; Smith and Baquet). In aggregate or county-level data, the goal is more often to explain the proportion of growers who choose to insure or the proportion of their land they choose to cover (Gardner and Kramer; Barnett, Skees, and Hourigan; Goodwin; and many others). However, both types of study fail to recognize that the decision to insure in fact encompasses two separate, but interrelated decisions. Participants in the federal multiple peril crop insurance program (MPCI) choose from among three coverage levels: 50%, 65%, and 75%, meaning that they receive indemnities if their actual yield falls below 50%, 65%, or 75%, respectively, of their insurance yield.¹ Therefore, growers must not only choose how much of their land to insure, but the level of coverage as well. Hojjati and Bockstael pose a similar type of problem in which farmers choose from among a discrete set of crop and insurance alternatives. They, too, however, assume only one coverage level. Models that do not account for the sample selection process involved in first choosing a coverage level not only invite sample-selection bias, but also ignore a potential source of valuable information.

¹ Although growers can now select from a greater number of coverage levels, a vast majority (>95%) of growers in the California grape data set used here chose one of these three levels.

While ignoring the choice of coverage level may be more tenable for relatively homogeneous field crop growers, this assumption is not acceptable for fruit growers. Moreover, because the policy reform proposal focuses specifically on increasing the price of one coverage level, differentiating between the demands for each is necessary to make meaningful comment on the effects of the proposed change. Fortunately, this bias is easily overcome and the information readily recoverable.

In micro data, Cragg develops a model of discrete/continuous choices where the decision is whether to buy or not followed by a model of the amount to buy. In the case of MPCID demand, however, the choice among coverage levels involves more than one alternative. Lee extends Cragg's model to the case where a continuous quantity decision for alternative s is only observed if a the decision maker chooses category s from among several mutually exclusive alternatives. Dubin and McFadden provide an illustration of this approach to the study of household electricity and electrical appliance demand. Similarly, Hanemann develops a model of discrete/continuous brand and quantity demand that is grounded in a single utility maximization problem, but places severe restrictions on estimated price-response parameters between the discrete and continuous sub-models. While this work is entirely theoretical, Chintagunta provides a recent application of Hanemann's approach to an empirical model of brand choice, purchase incidence, and purchase quantity. In this example, the discrete nature of his household scanner data necessitates that mutually exclusive alternatives be accounted for both at a brand and product-choice stage. With respect to the insurance-demand problem, the fundamental logic of this approach is the same — producers must decide simultaneously how much insurance to purchase and at which level of

coverage.²

Therefore, the model of insurance demand developed here uses a two-stage approach to account for growers' choice of coverage level and amount of insurance. In the first stage, a multinomial logit model is used to calculate the probability that growers in each county choose coverage level k . This fitted probability is used to calculate a correction factor similar to the inverse Mill's ratio employed by Heckman which, when included in a continuous model of insurance demand, corrects for the sample selection bias caused by growers' choice of coverage level. This second-stage model differentiates between the determinants of growers' demand for a minimal level of protection (50% coverage) or a more comprehensive level (75%). Obtaining elasticity estimates that vary by coverage level is critical as recent proposals for further crop insurance reform have considered raising premiums for only the lowest level of coverage. Intended to improve the financial viability of public crop insurance, such rate increases may instead drive the very growers most vulnerable to loss from the insurance program — those for whom the likelihood of a greater than 50% loss is the greatest. By using Lee's generalized selection procedure to estimate each second-stage equation, the two-stage model provides consistent estimates of the factors that determine the probability of purchasing each type of insurance, as well as the factors that drive aggregate participation rates.

Therefore, the objectives of this research are to determine the factors that contribute to a grower's decision among insurance coverage levels, and the decision as to how much insurance to

² As with other studies using county-level data (Gardner and Kramer; Hojjati and Bockstael; Goodwin 1993) this study adopts the convention of regarding each county as a representative grower. Therefore, the dependent variable in question is a continuous measure of the proportion of land insured, rather than the discrete participation choice used by studies with farm-level data (Coble, et al.).

buy. By estimating price elasticities of demand for insurance that vary by coverage level, this study will be able to determine the differential effects of an across-the-board premium increase on the choice of coverage level or, more importantly, of the effects of a premium increase targeted to one coverage level on aggregate participation rates. These elasticities are important as legislators debate the merits of changing the cost of catastrophic insurance — insurance that often represents the last line of defense for marginal growers. Another objective of this research is to determine whether insuring growers of a particular specialty crop, grape growers in this case, is subject to the problem of adverse selection that is common among insurance for field crops (Arrow; Just, Calvin, and Quiggin; Coble; Knight and Coble).

In order to estimate models of the decision to insure and the choice of coverage level, the paper begins with the development of an empirical model that is consistent with a grower maximizing expected utility in two stages. The next section presents an econometric approach that produces consistent parameter estimates of an aggregate insurance participation model while allowing for selection from among several discrete types of insurance. A description of an application of this approach to California grape growers follows. The remainder of the paper presents and discusses the empirical results of this application, including both the immediate implications of proposed changes to catastrophic insurance premiums and to crop insurance in general.

An Empirical Model of Insurance Demand

A grower's decision to purchase multiple-peril crop insurance encompasses two related decisions:

how much to insure, and the level of coverage.³ The amount of insurance purchased, however, is only observed if a particular coverage level is chosen. Therefore, simple ordinary least squares estimates of insurance demand equations at each coverage level will be biased (Lee). Because the two decisions are logically dependent upon each other, the empirical procedure employed must reflect this fact to ensure consistent parameter estimates. Therefore, this study uses the two-stage discrete / continuous multinomial selection approach suggested by Lee.⁴ This method is similar to the familiar Heckman correction procedure, but because growers face more than two coverage alternatives, the selection process is multinomial rather than binomial. Consequently, at the first stage growers' decide between coverage levels according to the aggregate multinomial choice model of McFadden, while the second stage consists of separate, linear models of the amount of insurance bought.⁵ Not only does this approach yield consistent insurance demand parameter estimates, but by allowing the estimation of coverage-level specific demand models, provides more meaningful response elasticities than are currently available in the literature. Although the standard errors at this stage are inconsistent due to the estimated regressor problem, they are corrected using the asymptotic covariance matrix also described by Lee.

Formally, the insurance decision consists of a continuous participation equation similar to

³ Formally, the multiple-stage decision process also includes a price-election as well, but because this price is based on a market price, it is more appropriately thought of as exogenous and included in the measure of total liability. Further, there are often dozens of prices that apply to any one county each year, so it is not practical to include these in the discrete/continuous choice framework developed here.

⁴ Although Lee develops his formal proof in terms of a univariate logit model, he suggests that extension to a multinomial framework is straightforward and provides a sketch of a proof of this. Allenby and Rossi demonstrate the consistency of the multinomial logit model in representing an aggregation of individual choice probabilities to market proportions in the context of consumer brand choice.

⁵ The logic behind this model is most clear if expressed as a sequential process, but neither the logical or statistical consistency of this model requires the actual decision process to be sequential.

Goodwin (1983) where the percentage of eligible acres insured by a representative grower solves an expected utility maximization problem:

$$MAX_y E[V(y_k; R_k^g, \epsilon_{1k})], \quad (1)$$

where R_k^g is grower g 's random net revenue under coverage level k (net of operating costs and insurance premia), y_k is the amount of insurance purchased at coverage level k , ϵ_{1k} is a random error term, and V is a well behaved utility function. In this expression, R_k^g is equal to the level of market returns if no indemnifiable loss is incurred, or is equal to the insurance liability if a claim is made. Approximating growers' expected utility using a second-order Taylor series expansion provides an expression for grower g 's level of utility that consists of a deterministic and random component (Hojjati and Bockstael; Calvin). Writing the deterministic component in terms of the first and second moments of the distribution of revenue facing each grower, a grower's expected utility from insuring at a coverage level k becomes:

$$E[V_k^g] = \bar{V}_k^g + \epsilon_{1k}^g = v_k + E[R_k^g] - (\rho^g/2) Var[R_k^g] + \epsilon_{1k}^g, \quad (2)$$

where v_k represents a choice-specific preference parameter, $E[R_k^g]$ is grower g 's expected net revenue, $Var[R_k^g]$ is the variance of net revenue, ρ^g is the coefficient of absolute risk aversion for grower g , and ϵ_{1k}^g is a random error term. Solving this problem produces an expression for the optimal amount of insurance:

$$y_k = Z_k^g + \epsilon_{1k}, \quad (3)$$

where Z_k^g is a vector of other factors that influence the expected utility of insurance, including the

mean and variance of R_k^g , attitudes towards risk, and various self-insurance strategies. In this application, however, the amount of insurance purchased at each coverage level (y_k) is only observed if the particular coverage level k is chosen. A grower's choice of coverage level is, in turn, determined by the value of an unobserved index of coverage-level expected utility, $E[U(R_k^g)]$, which is also defined over the level of net revenue. Assuming growers are risk averse, and that net revenues are inherently random, a grower's choice of coverage level reflects the relative expected utility of net revenue available from each option. In a random utility framework (McFadden), the probability that a grower chooses coverage level k (ie. that y_k is observed) is given by the conditional probability that the expected utility from doing so is greater than all the alternatives, given that the grower has chosen to insure. Mathematically, this decision is written as:

$$P(k=1|i) = P(E[U(R_k^g)] \geq E[U(R_j^g)], \forall j \in K), \quad (4)$$

Again approximating growers' expected utility of coverage choice using a second-order Taylor series expansion, a grower's expected utility from insuring at a coverage level k becomes:

$$E[U_k^g] = \bar{U}_k^g + \epsilon_{2k}^g = u_k + E[R_k^g] - (\rho^g/2) Var[R_k^g] + \epsilon_{2k} = X_k^g + \epsilon_{2k}^g, \quad (5)$$

where u_k represents a choice-specific preference parameter and the other variables are as defined above. Although this mean-variance approach is subject to some criticism, primarily due to the assumption of normality and quadratic utility (Newbery and Stiglitz), it nonetheless remains a common maintained hypothesis and has a considerable body of empirical support (Hojjati and Bockstael). Assuming this simple linear specification for each grower's random utility, grower g

chooses option k according to a given realization of the random error term, ϵ_{2k}^g . Assuming ϵ_{2k}^g are type I extreme value distributed (McFadden), the conditional coverage choice probability is:

$$P(k = 1 | i) = \frac{\exp(\bar{U}_k^g)}{\sum_j \exp(\bar{U}_j^g)}, j \in K, \quad (6)$$

which is the familiar multinomial, or conditional logit choice model. In estimating an aggregate multinomial logit model, the probability of choice k is simply replaced by the sample relative frequency of choice k , as described in more detail below. Using Lee's two-stage framework, this probability is then substituted into the insurance participation equation in (3) to obtain consistent estimates using least squares.

Specifically, assuming the marginal distributions of the ϵ_{1k}^g are $N(0, 1)$, the estimated participation rate equation becomes (Lee; Maddala):

$$y_k = \mathbf{Z}_k^g - \rho_{1k} (J_{1k}(\mathbf{X}_k^g))/P(\mathbf{X}_k^g) + \epsilon_{2k}^g, \quad (7)$$

where ρ_{1k} is the correlation coefficient between ϵ_{1k}^g and ϵ_{2k}^g , ϕ is the standard normal density function, and J_{1k} is the transformation function: $J_{1k} = \phi^{-1}P_k$. This equation is estimated consistently with least squares. Given the choice of coverage level k by a representative grower g in each county and aggregating over all growers in a county, \hat{y}_k therefore provides estimates of the marginal effects of county and choice-specific factors on the decision to insure, or the aggregate participation rate. Likewise, aggregating over all growers in each county in the coverage level model, $\hat{\beta}_k$ are interpreted as the marginal utilities of each coverage attribute. The next section describes the determinants of coverage choice and participation at the county level in more detail.

At the coverage-choice stage, the components of \bar{U}_k determine the proportion of growers choosing each coverage level. Specifically, the utility index is given by:

$$\bar{U}_k = \beta_0 + \sum_j \beta_1 E[P_j] + \sum_j \beta_2 Var[I_j] + \beta_3 E[R] + \beta_4 Var[R] + \beta_5 T, \quad (8)$$

where: $E[P_j]$ = expected premium for coverage level j ;
 $Var[I_j]$ = variance of indemnities for coverage level j ;
 $E[R]$ = expected market revenue;
 $Var[R]$ = variance of market revenue;
 T = time trend.

The determinants of expected utility at this stage thus reflect the relative desirability of each coverage level, the particular risk-history of growers in each county and their expectations of a profitable return to choosing a particular coverage level. Therefore, the elements of \bar{U}_k include the mean and variance of both market returns and the first- and second-moments of the returns to insurance (Coble et al.). Specifically, arguments of the choice model (8) include the county-level expected net premiums, or premiums net of expected indemnities and government subsidies. Expected indemnities are calculated assuming a truncated normal yield distribution for each coverage level and county as described below (Goodwin 1984). Because of the lower probability of a yield falling below 50% of the historical average compared to 65% or 75%, expected indemnity falls with coverage level. However, premiums for lower coverage levels, determined by the FCIC to be actuarially sound, are also correspondingly lower. By including the expected net premium of each coverage level in each utility index, the results from this stage will provide information on growers' willingness to substitute between coverage levels due to changes in relative prices. It is expected that the probability of a grower's choice of a particular coverage

level should fall in the relative expected net premium. Assuming growers maximize expected utility as described above, coverage choice depends upon the relative variability of the returns to each coverage level as well. Because growers with only CAT-level insurance face constant premiums, the variance in returns to insurance is measured by the historical variance of indemnities. While it is clear that the probability of a coverage choice should also fall in the expected variability of expected indemnities, the response of coverage choice to the variability of market returns is less obvious.

In fact, both the first and second moments of the distribution of market returns have direct effects on the amount of insurance purchased because they reflect the relative utility of buying versus not buying insurance. However, market returns also have an indirect effects on coverage choice. While the distribution of market returns is the same for each choice of coverage level, it is likely that growers who are relatively certain of their revenue stream may choose only an inexpensive safety-net level of coverage. However, a grower who is more uncertain over his market returns may regard a higher coverage level as a necessary alternative source of income in the event of even a moderate loss. This is particularly important in produce markets where individual growers in counties that produce a large proportion of the output of a commodity are often compensated with increases in the market price when significant crop losses occur (Lee, Harwood, and Somwaru). Although the expected market revenues for these growers may be relatively constant, the reduced supply from growers in relatively minor producing regions does not influence the market price, so their revenue loss is proportionate to their yield shortfall. Finally, including a time trend in this model is intended to capture changes in growers' attitudes towards crop insurance and their experience with the program. At the second-stage, or quantity-

of-insurance level, however, the determinants of growers' expected utility from insurance include not only variables that reflect the relative return to insuring versus not insuring at each coverage level, but also the extent to which they self-insure through enterprise diversification or other means. This decision is also affected by a grower's subjective attitudes towards risk.

At the county level, aggregating representative growers' insurance decisions for each county means that the insurance-quantity model consists of a participation-rate equation for each coverage level. Knight and Coble review the extensive literature on models of aggregate participation in MPCCI among field crop growers. Among this body of work, alternative measures of the aggregate insurance participation rate include either the proportion of eligible acres insured in each county (Gardner and Kramer; Hojjati and Bockstael; Barnett, Skees, and Hourigan; Goodwin 1993), the change in MPCCI participation between two sample years (Cannon and Barnett), or liability per acre (Goodwin 1993). Although Goodwin finds significant differences between parameter estimates for each dependent variable, this study adopts a proportion of acreage measure for the sample of California grape growers. Many argue that the primary weakness of using county-level data for this type of analysis is that it masks the farm-level variability that drives growers' decisions to insure (Goodwin and Kastens). Therefore, using a liability measure of participation is likely to worsen this problem, particularly in a model that differentiates between coverage levels, because it is more likely to be skewed by outlying observations.

Defining participation in this way, the estimated version of equation (7) becomes:

$$y_k = \beta_0 + \beta_1 E[P_k] + \beta_2 Var[I_k] + \beta_3 E[R] + \beta_4 Var[R] + \beta_5 T + \beta_6 T\% + \beta_7 R\% + \beta_8 INC + \beta_9 GR\% + \beta_{10} LV\% + \beta_{11} SZ + \beta_{12} k + \epsilon_{1k}, \quad (9)$$

where variables unique to this stage include:

$T\%$ = proportion of county grape acreage in table grapes;
 $R\%$ = proportion of county grape acreage in raisin grapes;
 INC = average income from farming;
 $GR\%$ = average proportion of farm enterprise in grape production;
 $LV\%$ = average proportion of farm enterprise in livestock;
 SZ = average size of grape enterprise (acres);
 k = Lee's multinomial correction factor.

Among other insurance demand studies, definitions of the price of insurance are as diverse as those for the participation rate. Gardner and Kramer use an expected returns to insurance variable, defined as the ratio of expected indemnities less premiums to premiums paid. While this variable is expected to have a positive effect on participation, others define the cost of insurance as premiums per acre (Goodwin) or as premiums net of expected indemnities per dollar of liability (Cannon and Barnett). Hojjati and Bockstael use not only the expected profit with insurance, but its variance as well. At the grower-level, Coble et al. define a similar, yet more comprehensive set of insurance incentives consisting of the first- and second-moments of the expected returns to insurance and expected returns to non-insurance, or market participation. As in Hojjati and Bockstael, these variables are derived from a theoretically correct model of grower expected utility maximization, so are consistent with the arguments developed here. Irrespective of the particular definition, each of these studies interprets a positive relationship between expected indemnities and participation as evidence of adverse selection. Goodwin extends this "test" by specifying an interaction term between price and measure of county loss-risk, or the relative riskiness of a particular county. A negative interaction effect means that growers in riskier counties are more sensitive to changes in the cost of insurance and are thus more likely to leave

the market if faced with higher premiums. In this study, the arguments in (9) suggest a test for adverse selection similar to that found in Coble et al.

Whereas the coverage choice model includes the mean and variance of expected premiums for all coverage levels in each levels' set of attributes, at the insurance-quantity level each equation includes only the expected net premium and indemnity variance unique to that coverage level. These expected indemnities are calculated using a method similar to Bott and Boles as described by Goodwin (1984). With this method, FCIC premia, and hence expected indemnities if the program is actuarially sound, are the product of an insured-price and the expected loss from a normal yield distribution truncated at the chosen coverage level. For each county i and coverage level k , therefore, expected indemnities are calculated as:

$$E[I_{ik}] = \bar{P}_{ik} \left(\left(\frac{\mu_{iky} - \mu_{iky}}{\sigma_{iky}} \right) + \left(\frac{\mu_{iky} - \mu_{iky}}{\sigma_{iky}} \right) \sigma_{iky} \right) \quad \forall i, k, \quad (10)$$

where ϕ and Φ are the normal distribution and density functions, respectively, μ_{iky} is the average yield, and σ_{iky} is the standard deviation of yield for each county and coverage level. These values are calculated using the entire sample history of each county. Because (10) provides indemnities units of yield (ie. tons per acre), calculating a money premium requires each to be multiplied by a reference price, \bar{P}_{ik} which is the average price election for each county and coverage level. Further, because expected indemnities vary only by county and coverage, their variance is found from historical indemnity data. Calculating expected indemnities in this way highlights the necessity of considering each coverage level separately. Whereas Coble et al. dismiss the fact that they exclude the 11% of growers from their sample who do not choose a 65% coverage level as

inconsequential, it is likely that these growers differ fundamentally in their demand for insurance and so provide a valuable source of information to the model. However, similar to their study, the model developed here also includes variables measuring expected market returns and the variability of market returns. Assuming naive expectations, $E[R]$ is equal to lagged average grape-revenues, while the variability of returns is found by calculating the variance of historical revenues for each county over the entire sample period. If the results show a positive relationship between participation and the variability of market revenue, then adverse selection is likely to exist. Most of the existing research in this area, however, shows that insurance participation depends not only upon relative returns to insurance, but also growers' willingness and ability to self insure.

The tendency to self insure is captured by including variables describing a typical grape grower in each county, thereby accounting for unobserved heterogeneity among counties, the effect of size economies on the tendency to insure, and the extent of financial, operational, and geographical diversification. First, there may be an inherent difference between raisin, table, and wine grape growers to insure. For example, whereas all growers all growers face similar yield variability at harvest (depending upon variety), raisin growers face the added risk that arises during drying. By excluding the proportion in wine grapes, which is required in order to avoid singularity, the estimated parameters on these variables define the tendency of table and raisin grape growers to insure relative to wine growers. Second, many studies include a measure of farm size to capture the effect of size economies on the demand for insurance (Barnett, Skees, and Hourigan; Cannon and Barnett; Nieuwoudt et al.; Goodwin) but do not differentiate between physical and economic size. Therefore, this study includes both acreage and total farm income.

Whereas growers with operations spread over large areas may benefit from geographic diversification, high income growers may be more able to afford insurance. On the other hand, if growers attitudes towards risk are subject to decreasing absolute risk aversion, then wealthier growers may also perceive less of a need to insure. Third, similar to Barnett, Skees, and Hourigan and Cannon and Barnett, the participation model (9) includes two measures of enterprise diversification: the dominance of a single crop (grapes) and the extent of diversification into livestock. While these two studies confirm *a priori* expectations by finding a negative relationship between the extent of diversification into livestock and the tendency to insure, Goodwin (1993) does not. Goodwin's result is perhaps not surprising as diversification may reflect two opposing influences on the demand for insurance. Whereas growers who successfully diversify into other enterprises may require less insurance, many growers who choose to diversify may instead be signaling themselves as inherently more risk averse and, thereby, more likely to insure *ceteris paribus*. Therefore, which of these effects dominates is likely to depend on the particular application and data set.

Data and Methods

Data for this analysis are from FCIC, California Department of Food and Agriculture (CDFA), and Bureau of Census sources. The insurance data includes county-level measures of the number insurance contracts, total premiums, liabilities, and indemnities at each coverage and price election level for the years 1986-1996. Although FCIC records include many more counties than those considered here, the data used in this analysis includes the eleven counties for which there are eleven consecutive years of data in both the insurance and grape production data. Data on

historical grape production performance was provided by CDFA officials, as compiled from county agricultural commissioners' reports, and includes county-level harvested acres, total production, average yield, and average prices disaggregated by intended usage (wine, table, or raisin). Because of changes in the types of grape insurance contracts offered over the sample period, the actual choice of coverage level in recent years goes somewhat beyond the 50/65/75 used here. However, very few growers chose levels other than these standards and in only one or two counties. For example, in Fresno county in 1996, 15 of 2400 premiums paid were covered at a 70% level. These growers were, therefore, included with the 75% coverage group as this option was not available in other years.

Similarly, other studies of field crop insurance programs report relatively homogenous price-election levels. For grapes, however, the data typically consist of upwards of twenty price election levels for each county/coverage/year observation. Therefore, insurance prices are averaged across all election levels. Data on farm income, size, and enterprise diversification are from the 1982, 1987, and 1992 editions of the *Census of Agriculture*. The resulting data set provides 121 panel observations that are used to estimate both the coverage choice and aggregate participation models. For each model, consistent parameter estimates are obtained using the methods described next within a general fixed effects estimation framework.

Whereas some studies in the consumer demand literature use simultaneous methods to estimate household-level discrete/continuous choice models (Chintagunta), the method used here is Lee's two-stage estimator, as described above. Although simultaneous estimation is more efficient, sequential estimators remain consistent and place less demands for parsimony in specifying the model. With Lee's approach, the coverage-choice stage is estimated with

maximum likelihood while independent participation models, including β_k , are estimated with least squares. Although this method provides consistent second-stage parameter estimates, their standard errors are not. Consequently, estimates of the correct asymptotic covariance matrix are found using the procedure outlined by Lee and described in detail by Greene. The following section provides a discussion of the results obtained by estimating both stages of the model in the California grape grower data.

Results and Discussion

In order to address the research objectives outlined above, the key results presented here concern both the elasticities of demand for insurance at each coverage level and the determinants of coverage choice. Specifically, a comparison of price elasticities between coverage levels indicates whether premium changes are likely to have different effects on the participation rate in each. Further, including the variability of market returns permits a test for adverse selection. Although the coverage and quantity decisions are assumed to be taken simultaneously, this section presents the results of the coverage model first.

Identification of the coverage choice model parameters requires one of the discrete choice indicators in the multinomial logit model to be normalized to zero. Therefore, the structural parameters consist of marginal utilities of attributes of the selected coverage levels (either 50% or 75%) relative to the excluded alternative (65%). Initial parameter values for this model are obtained by specifying a “null” model where all $\beta_k = 0$ except for the choice-specific intercept value. This null model also serves as a benchmark against which we compare the fit of the final choice model. Because the null model is nested in the more complete model with non-zero β_k , a

likelihood ratio test statistic is valid. By this statistic, the coverage model provides a good fit to the data as the chi-square value of 75.49 is far greater than the critical value of 28.87 at 18 degrees of freedom. Table one provides all parameter estimates from this stage.

[table one in here]

In this table, the structural parameters are interpreted as marginal utilities with respect to each explanatory variable. As expected, the utility from each coverage level falls in its own net premium level, but rises with premiums in the closest alternative. In terms of the choice elasticities, both the 50% and 75% alternatives are highly inelastic, suggesting that growers tend to be coverage-loyal and are not likely to change due to small changes in premiums or expected indemnities. This implication is supported by the low cross-elasticities with respect to premiums at a 65% level -- large changes in net premiums are required to induce growers to change their level of coverage. Moreover, the insignificant marginal utility of 75% premiums in the 50% choice equation, and vice versa, implies that growers at either extreme do not consider the other as a viable substitute. Targeted premium changes at each level, therefore, are likely to drive growers either towards 65% coverage, or out of the market. This latter possibility, however, is answered by the price-elasticities of participation, which are discussed after the remaining variables of this model.

In particular, perhaps again as expected, the utility from each choice falls in the variability of expected indemnities. In terms of choice elasticities, however, the variability of returns to insurance has very little impact on the choice of 50% coverage, but a significantly greater effect on the probability of choosing 75% coverage. This is also true with respect to the cross-elasticities -- the variability of indemnities at the 65% level has a relatively large impact on the

probability of choosing a high level of coverage, but little effect on the lowest level. Both the own and cross-elasticities suggest that growers who choose a minimal level of insurance are less sensitive to risk, a result that is indeed consistent with their choice of coverage. Although some may interpret these results as implying the existence of adverse selection, this is not necessarily the case in the choice model because the probability of choosing 50% coverage rises in the variability of expected indemnities at a 75% level. This suggests that such changes have significant allocative effects, but does not address the participation question raised by adverse selection. The variability of market returns, however, has a distinctly different effect at each level.

Namely, positive choice elasticities at both the 50% and 75% levels with respect to the variability of market revenue suggests that growers respond to greater market-based uncertainty by, in general, moving away from an intermediate (65%) level of coverage. While many respond by establishing a floor on their returns (CAT insurance), others seek coverage that will leave them relatively whole following an indemnifiable event (75%). Note, however, that the choice parameters with respect to the variability of indemnities are significant only at a 10% level. Further, these results provide some, albeit weak, statistical support for a negative effect of higher expected market returns on each coverage choice. While higher expected market revenue may allow some growers to be able to afford more comprehensive insurance coverage, it may also cause others to lower their coverage level to achieve a target level of liability. However, the aggregate participation parameters and elasticities provide both a more direct test for adverse selection and more complete evaluation of the policy implications of a premium increase.

These results are shown in table two. Legislators and policy analysts' interest lie primarily in these parameters as they reflect the constraints on federally-underwritten crop insurance as a

viable agricultural policy tool. In particular, the two criteria by which these programs have been judged in recent years are aggregate participation rates and loss ratios. If participation is price-inelastic, then financial viability may be improved by a premium increase. However, if participation is price-elastic, then a premium increase (or a reduction in subsidies) will reduce participation proportionately more than the increase in premiums (Goodwin 1993). As a result, program performance suffers by both measures.

[table two in here]

In the grape insurance example, the price-elasticity of participation at the 50% coverage level is -1.252, while the elasticities at 65% and 75% are -0.276 and -0.492, respectively. This suggests that an increase in CAT insurance premiums is likely to cause a relatively large number of growers to leave the program altogether, reducing the actuarial soundness of the CAT program. This result should be of particular concern given California growers' expressed desire for an effective and affordable risk management tool (Blank and McDonald). However, premium increases at both the 65% and 75% levels may indeed have the desired effect of raising program revenue without drastically reducing participation rates. Clearly, this suggests that the FCIC can improve the overall financial performance of the program through price discriminating between growers who choose to insure at different levels. This result is not unexpected as growers who choose CAT-level insurance are likely those who are at the margin between insuring and not insuring. While the elasticities at 65% and 75% are consistent with those found by previous researchers (see Knight and Coble and references therein) none report elastic demand. Our results suggest that this discrepancy may be due to their failure to differentiate between participation at different levels of coverage. Nonetheless, the implications of an elastic demand for insurance are

likely to be more severe if participation is also subject to the common problem of adverse selection.

In this model, growers' response to the variability of expected indemnities provides information as to their aversion to risk, while their response to variability in market revenue provides evidence of adverse selection. In table 2, growers at the 50% and 75% levels are less likely to insure the more variable are the returns to insurance simply because insurance offers less of a benefit to market returns. However, growers are more likely to insure at their chosen coverage level the more variable are market returns. This constitutes evidence of adverse selection. Note, however, that growers who choose 65% coverage do not exhibit adverse selection. This suggests that adverse selection is not a universal phenomenon for all growers, but arises only with those who tend to view insurance as an alternative to the market (75% coverage) or those who seek only minimal protection at virtually costless premiums. The majority of growers who use insurance as part of an overall risk-management plan, therefore, tend not to be those who are adversely selected into the insurance market. Such growers may also be more likely to self insure than growers who tend to rely more on FCIC insurance.

Self insurance may be achieved through either financial or operating strategies. Whereas many studies use capital structure (debt:equity ratio) as an indicator of a grower's degree of financial risk, this data is not available on the current sample of California grape growers. Net income, however, may serve as a measure of the financial strength of a grower's operation. As such, a higher level of net income may have competing effects on the tendency to insure. More profitable growers may be more able to afford insurance, but assuming DARA, these growers may be less likely to choose to insure. The results in table 2 provide support for the latter effect,

although the parameters are not significant at a 5% level. On the other hand growers with larger operations in terms of acreage may be able to reduce the variability of their returns by farming geographically disperse land-holdings that face less-than-perfectly correlated weather patterns. Again, the results in table 2 provide only limited support for this hypothesis and only in the 75% coverage case. The sharp contrast of this result to that of Goodwin (1993), who reports a significant positive effect of average farm size on participation, may be due as much to differences between grape and wheat growers' risk attitudes as it does their ability to diversify geographically. From an operational standpoint, perhaps a more viable method of smoothing earnings is through enterprise diversification.

By this reasoning, if a grower focuses on only one commodity then he or she is more likely to insure as a means of preventing the loss of an entire year's revenue. In fact, this study finds the opposite for growers choosing either of the 65% or 75% coverage levels. It may be the case that, by growing only one crop, these growers are signaling their relative lack of aversion to risk. This result could also be due to the relative expertise of growers who specialize in one crop, believing that insurance is only valuable to those who are less skilled in growing grapes. A common measure of diversification among studies of the demand for insurance among Midwestern farmers is the percentage of farm production value due to livestock (Cannon and Barnett). While this represents a natural portfolio choice for these growers as their grain output can be used as an input to their livestock enterprise, livestock diversification among grape growers is less common. Nonetheless, counties with a higher percentage of farm production in livestock have significantly lower insurance participation rates at the 65% and 75% coverage levels compared to other counties. This result is consistent both with *a priori* expectations and

the empirical results of Barnett, Skees, and Hourigan and Cannon and Barnett for wheat and corn growers, respectively. Other variables in the participation rate model are intended to capture the impact of heterogeneity among growers in different counties that is otherwise unexplained.

Because the cultural practices associated with growing grapes for alternative end uses differ somewhat, it is likely that their demand for insurance will differ as well. Using wine-grape growers as a benchmark, raisin-grape growers are significantly less likely to insure at the 75% level, but significantly more likely to insure at a 50%, or catastrophic level. Given the price-elasticity results above, this means that a targeted premium increase is likely to have distributional effects among growers, impacting raisin growers proportionately more than others. On the other hand, table grape growers are significantly more likely to insure at a 75% level, suggesting that they would be relatively indifferent to the proposed premium increase. Growers as a whole, however, are not likely to support such a proposal given the overall trend towards choosing a minimal coverage level. In fact, the inertia towards 50% coverage is the most significant determinant of the demand for coverage at each level. If growers feel the government's commitment to abandon the business of disaster support is credible, this result is to be expected as growers begin to take greater responsibility for their own risks, however small the probability of an indemnifiable loss may be.

Conclusions and Implications

Continuing concern over the financial viability of the federal multiple-peril crop insurance program, in particular the catastrophic or CAT level of insurance, has led to demands from legislators that premiums for this coverage be increased. However, if the demand for CAT

insurance is price-elastic, then higher premium rates will not only reduce the total amount of premiums paid into the system, but decrease participation rates as well. Neither of these outcomes is consistent with the goals of the federal crop insurance program. This concern is particularly acute among produce growers who, facing relatively low probabilities of indemnifiable losses, tend to prefer coverage at this minimal, safety-net level of insurance. Existing studies of the demand for crop insurance do not differentiate between the demand for different coverage levels, so are unable to determine whether there is a difference in the price elasticity at each level. Because the majority of these studies find the demand for crop insurance to be price-inelastic, the policy recommendations that follow would be opposite to those suggested by a finding of elastic insurance demand.

In order to account for differences in the structure of demand among coverage levels, this study applies a two-stage empirical method suggested by Lee. With this approach, growers are assumed to choose the amount of insurance they wish to buy and the coverage level in two separate, but interrelated decisions. Formally, a grower's purchase of insurance is only observed once a choice of coverage level is made, so the coverage choice serves as a sample-selection mechanism for a set of continuous insurance demand models. By controlling for this multinomial selection problem, the participation elasticities for each coverage level estimated at the quantity stage are not only consistent in a statistical sense, but more relevant for policy analysis than single-coverage elasticities. We demonstrate an application of this method to a county-level sample of insurance choice and participation rates by California grape growers over the period 1986 - 1996.

Determinants of both the demand for insurance at each level and the choice of coverage

level include the mean and variance of the returns to insurance, as well as the mean and variance of market returns. The study finds empirical support for each of these variables. More importantly, however, the results show the demand for insurance at a 50% coverage level to be elastic, while higher coverage levels are inelastic in demand. Thus, the proposed premium changes would have the perverse effects cited above. Growers at both the 65% and 75% levels are also more likely to insure the greater the variability of their market-based returns. This suggests that adverse selection is likely to exacerbate the participation problems caused by a premium increase. Because the least-adversely selected growers are the first to drop out, the remaining growers will tend to be the worse risks, so indemnities will likely rise due to this indirect, unintended side effect as well.

The most obvious implication of this research is that, if the FCIC desires to improve the financial viability of specialty crop insurance, then price discriminating among coverage levels is likely to be a more effective strategy than a targeted premium increase. Following policies implied by studies using coverage-aggregated data and Midwestern field-crop growers is likely to worsen, rather than improve, the performance of multiple peril crop insurance for produce growers.

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Table 1. Multinomial Logit Coverage Choice Parameter Estimates: California Grape Growers: 1986-1996

Variable:	50% Coverage			75% Coverage		
	Estimate ¹	t-ratio	Elasticity	Estimate	t-ratio	Elasticity
Constant	-46.112*	-3.841		16.321*	4.404	
E[Prem50]	-0.059*	-2.313	-0.091	-0.014	-0.168	-0.014
E[Prem65]	0.039*	2.748	0.134	0.024*	2.616	0.188
E[Prem75]	0.001	0.098	0.003	-0.025*	-2.441	-0.068
V[Indem50]	-202.490*	-5.946	-0.001	-10.275*	-6.924	-0.552
V[Indem65]	-28.284*	-5.982	-0.005	1.456*	6.524	0.845
V[Indem75]	2.353*	6.031	0.050	-0.125*	-3.399	-0.293
V[Rev]	1.576	1.616	0.085	0.604	1.717	0.042
E[Rev]	-0.003	-1.878	-0.072	-0.006	-1.593	-0.127
Year	0.523*	3.963	3.893	-0.163*	-3.261	-0.829
LR ²			75.490			

¹ A single asterisk indicates significance at a 5% level.

²The chi-square likelihood ratio statistic is $LR = 2(LLF_U - LLF_R) \sim \chi^2_q$ which compares the estimated model with a null model, $\beta = 0$. The critical chi-square value at 18 degrees of freedom at a 5% level of significance is 28.869.

Table 2. California Grape Growers' Insurance Demand by Coverage Level: 50%, 65%, 75%, 1986-1996.

	Coverage Level								
	50%			65%			75%		
	β_1	t-ratio	β_2	β_3	t-ratio	β_4	β_5	t-ratio	β_6
Constant	-3.031*	-9.685	-2.812*	-3.072	5.465*	6.458			
E[Prem]	-0.005*	-7.220	-1.252	-0.002*	-2.177	-0.276	-0.003*	-4.840	-0.492
V[Indem]	-0.020*	-3.980	-0.222	-0.002	-0.968	-0.058	-0.003*	-6.244	-0.221
E[Rev]	-0.001*	-3.801	-1.536	-0.001	-0.434	-0.151	-0.007*	-2.940	-0.500
V[Rev]	0.096*	2.673	1.024	-0.051	-0.456	-0.161	0.683*	6.853	1.235
Trend	0.035*	10.320	46.161	0.041*	4.064	16.148	-0.048*	-5.413	-10.660
Table %	-0.058	-0.625	-0.064	-0.153	-0.492	-0.050	0.574*	2.249	0.107
Raisin %	0.115*	2.419	0.327	-0.064	-0.404	-0.054	-0.343*	-2.502	-0.165
Income	-0.029	-0.735	-0.397	-0.163	-1.321	-0.650	-0.134	-1.259	-0.304
Grape %	-0.069	-0.710	-0.118	-0.975*	-2.969	-0.493	-0.143*	-4.887	-0.412
Livestock %	0.064	0.633	0.330	-0.936*	-2.436	-1.423	-0.122*	-3.858	-1.059
Firm Size	0.215	0.370	0.152	-0.461	-0.253	-0.096	-0.209	-1.287	-0.249
	0.003*	2.938	0.107	-0.008*	-2.068	-0.034	0.001*	2.040	0.017
R²	0.735			0.354			0.741		

¹ A single asterisk indicates significance at a 5% level. Variable definitions: E[Prem] = premiums net of expected indemnities and subsidies; V[Indem] = variance of expected indemnities; E[Rev] = expected market revenue; V[Rev] = variance of market revenue. Parameter definitions: β_i = coefficient vector for coverage level i, α_i = elasticity vector for coverage level i.

