Estimating Crop Yield Insurance Premium Rates

Daniel J. Dudek and P. Geoffrey Allen

Insurance rates for crop yield protection programs have traditionally been calculated from county average yields. Where grower acreages and yields are not homogeneous, this approach leads to higher premiums and payouts and greater incidence of adverse selection. With individual grower data a production weighted rate premium calculation method can be used which avoids these problems. Furthermore, the definition of rate classes is not constrained to county boundaries. The additional complication of technical change is addressed and one solution is provided. Results are presented for the cranberry industry.

Introduction

In 1980, Congress enacted the Federal Crop Insurance Act which was designed to expand the number and extent of crop insurance programs. The legislative intent was to improve the economic viability of farm firms faced with natural disaster and to allow a concomitant reduction in less efficient agricultural income transfer programs. Prior limits on the annual expansion of Federal Crop Insurance Corporation (FCIC) programs and restrictions on reinsurance provisions were removed. These changes had the additional effect of enabling private insurance firms to develop yield protection plans, termed all-risk crop insurance, with FCIC reinsurance against catastrophic losses.

While FCIC programs and coverage, measured in terms of insured acres, expanded approximately 81 percent in 1981, privately developed all-risk insurance programs have been noticeably absent [U.S. General Accounting Office]. This latter situation is changing and agricultural economists will have an opportunity to participate more widely in the design of insurance schemes for a wider range of crops.

This paper presents some of the issues encountered in developing yield insurance for cranberries as a pilot program under this policy initiative.

The cranberry industry was selected as the prototype project in response to grower requests, insurance industry interest and unique data availability. Massachusetts, Wisconsin, Washington, Oregon, and New Jersey are the cranberry producing states. The adoption of new technologies—specifically sprinkler systems, resanding procedures, improved fertilizers and pesticides, wet harvesting, and flooding to protect against winter kill—have alleviated many of the risks normally associated with cranberry production. However, in spite of these innovations, there are still risks associated with natural disasters and the vagaries of weather. Several examples include flooding and salt water intrusion (in Massachusetts) due to hurricanes and extreme storms, forest fires with resulting encroachment on the bogs themselves, extensive drought, excessive moisture, and winter kill. Although these events are rare, their occurrence can destroy an entire crop. Protection in the form of insurance against such disasters can contribute to a grower's economic viability.

The next section presents the basic theoretical framework for the estimation of pure premium rates. The primary approaches—distributional methods and direct empirical procedures—are assessed and the major theoretical problem of adverse selection is presented in the context of developing an all-risk crop

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The authors are Assistant and Associate Professor, Department of Agricultural and Resource Economics, University of Massachusetts, Amherst.

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insurance program. Succeeding sections detail the major empirical problems associated with the definition of classes for rate premium construction and adjustment for technological change. Insurance rates are calculated and a validation procedure described which illustrates the importance of selecting the correct basis for rate calculation.

A Theoretical Model of Rate-Making

There are a number of alternative approaches to the calculation of actuarially sound insurance premiums. However, the common objective in pure premium rate-making for all-risk crop insurance is the equalization of aggregate premiums paid by growers and aggregate claims paid by insurers over time. In this context, claims are paid out when realized yields fall below the contractually guaranteed level. Consequently, the appropriate focus in rate making analysis is the estimation of these claims or losses. Clearly, losses are a function of the guaranteed yield and the frequency and magnitude of actual yield outcomes below the guarantee. Since the guarantee levels are exogenous, in the sense that they are selected by producers before the growing season, the focus of the loss analysis is the distribution of yields. In general, the pure premium rate for a specific rate class, either a homogeneous production area or group, is the expected loss cost which is determined by the underlying yield distribution. Specifically, the product of the frequency and the severity of loss produce the loss cost history for the rate class.

Two major classes of methods have been distinguished—those employing theoretical probability distributions and those using empirical frequencies.

Examples of the first type are the premium rate-making methods employed by FCIC as described by Botts and Boles and elaborated by Yeh and Wu. Traditionally, the U.S. Department of Agriculture's crop insurance programs, as administered by the FCIC, have been implemented as areawide programs typically on a county basis. The expected loss cost L′ for these county-based programs may be written as:

$$(1)\quad L' = E(d\bar{Y} - y_k) = \sum_{k=1}^{K} f(y_k)\,(d\bar{Y} - y_k),$$

where $\bar{Y}$ is the contractually established county base yield; d is the proportion of that base which defines the guarantee level; y_k is the yield of acre k; the limit of summation K is the total number of acres with realized yields less than the guarantee; and $f(y_k)$ is the frequency function. Obviously, this approach requires knowledge of the distribution of yields below the guarantee.

We now turn to strictly data based methods. These determine expected loss cost solely on the basis of historical yield observations. They avoid the major weakness of the first class, which is the selection of an appropriate theoretical distribution to characterize crop yields. Although the normal curve of error originated from observations on biological responses, yield observations from a group of growers may not follow a normal distribution, nor need the variance of the distribution be constant over time. Factors such as changes in inputs, technology and weather can influence yield distribution. Finally, in attempting to fit a theoretical distribution to a set of yield observations, the overall goodness of fit is less important in ratemaking than the precision of representation of the lower tail up to the guarantee level.

Let y_{kt} be the yield on the kth acre in year t with $\bar{Y}_{kt}$ as the base yield for that kth acre in year t. This specification allows the possibility of individually tailoring the contractual base yield. Then losses on an individual acre L'_{kt} are dichotomous random variables:

$$(2)\quad L'_{kt} = \begin{cases} d\bar{Y}_{kt} - y_{kt} & \text{if } y_{kt} < d\bar{Y}_{kt} \\ 0 & \text{otherwise} \end{cases}$$

Suppose that there are M_t acres experiencing loss in year t and $(m_t - M_t)$ acres with no losses. The pure rate premium as a mathematical expectation is given by:

$$(3)\quad E(L') = E(d\bar{Y}_{kt} - y_{kt}) = \frac{\sum_{t=1}^{T} \sum_{k=1}^{M_t} (d\bar{Y}_{kt} - y_{kt})}{\sum_{t=1}^{T} m_t}.$$

The rate premium is most commonly expressed as a proportion of the guarantee level:

$$(4)\quad E(L) = \frac{\sum_{t=1}^{T} \sum_{k=1}^{M_t} (d\bar{Y}_{kt} - y_{kt})}{\sum_{t=1}^{T} \sum_{k=1}^{m_t} d\bar{Y}_{kt}}.$$

A common approach in ratemaking is to assume independence between the frequency of loss and severity. This separate treatment assumes that severity does not depend upon the factors affecting the frequency of claims (Weisberg and Tomberlin). It will enable us to discuss unweighted, production weighted and grower weighted loss cost formulations. Decomposition of the expected proportional loss (equation (4)) into the product of the probability of a loss and the average percent severity of a loss when it occurs results in:

$$(5)\quad E(L) = \left(\frac{\sum_{t=1}^{T} \sum_{k=1}^{M_t} d\bar{Y}_{kt}}{\sum_{t=1}^{T} \sum_{k=1}^{m_t} d\bar{Y}_{kt}} \right) \left(\frac{\sum_{t=1}^{T} \sum_{k=1}^{M_t} (d\bar{Y}_{kt} - y_{kt})}{\sum_{t=1}^{T} \sum_{k=1}^{M_t} d\bar{Y}_{kt}} \right).$$

The left half of the right-hand side is the probability of a loss expressed as the ratio of acres experiencing non-zero loss to total acreage. In the case of a county based program, the guarantee level $d\bar{Y}_{kt}$ is the same for every acre in the county with the result that this ratio collapses to the proportion of total acreage that experiences loss; i.e., $(\Sigma M_t/\Sigma m_t)$. The right half is the average percent severity computed as the number of acres with loss events ratioed to the guarantee level averaged over the total number of loss events. Clearly, this method of rate estimation is unweighted and does not account for the possibility that the probability of a loss might systematically vary with the yield level. An alternative programmatic approach to area-wide implementation utilizes individual grower records. This method was employed by FCIC in establishing firm-specific premium rates in the early years of its operations, but was abandoned by 1946 (Halcrow). However, when they are available, individual grower records could be aggregated into rate classes which are homogeneous with respect to the risk of a loss and these pooled data then could be used to estimate pure premium rates. This type of program would allow the introduction of a completely general method for rate calculation which compensates for the potential bias of the unweighted method above through production weighting. The actuarially sound rate premium is then given by:

$$(6)\quad E(L) = \left(\frac{\sum_{t=1}^{T} \sum_{j=1}^{N_t} \bar{y}_{jt} A_{jt}}{\sum_{t=1}^{T} \sum_{j=1}^{n_t} \bar{y}_{jt} A_{jt}} \right) \left(\frac{\sum_{t=1}^{T} \sum_{j=1}^{N_t} (d\bar{Y}_{jt} - y_{jt}) A_{jt}}{\sum_{t=1}^{T} \sum_{j=1}^{N_t} d\bar{Y}_{jt} A_{jt}} \right).$$

where y_{jt} is the yield per acre for the j^{th} production unit (grower) in year t and A_{jt} is the acreage of the j^{th} grower in year t. Symbol N_t represents the count of growers experiencing loss at time t, while n_t measures the number of growers at t. In this statement, the probability of a loss is expressed as the ratio of total expected production on acreage with losses to total potential production. If both grower acreages and yield levels are relatively homogeneous within an area (e.g., a county), then the probability of a loss can be expressed as before by the ratio (Σ_t/Σ_t). This would be a grower based method of calculating premium rates. The percent severity, the rightmost expression, is total losses paid out ratioed to the guaranteed level of total production for that acreage. Equation (6) can be simplified to:

$$(7)\quad E(L) = \frac{\sum_{t=1}^{T} \sum_{j=1}^{N_t} (d\bar{Y}_{jt} - y_{jt}) A_{jt}}{\sum_{t=1}^{T} \sum_{j=1}^{n_t} d\bar{Y}_{jt} A_{jt}}.$$

While expressions such as (5) have been proposed (Yeh and Wu), to our knowledge the more general result (7) has been neither suggested nor applied. The generality of a production weighted approach to ratemaking is critical to the actuarial soundness of the resulting premium rates. Since agricultural commodity production systems are highly dynamic, the effects of the intertemporal variability of both grower numbers and production levels must be considered.

Data Sources

Individual record sheets representing almost the entire population of cranberry growers were obtained from the Cranberry Marketing Committee (CMC). Each sheet contains a grower identification number, annual total production and acreage for up to 15 years in the period 1968–82. Production data are reported by handlers and processors in 100 pound barrels, net of culls. There are occasional additional notations to explain unusual production events; e.g., frost kill. Since records are maintained on the basis of legal entities, it is possible for the same individual to operate under a number of identification numbers, and also to change form of ownership, and hence identification number in the data period. Consequently, it was not possible to aggregate the CMC's individual records into continuous farm firm enterprises. Average annual yields were calculated for each identification number. In order to locate each entity, these numbers were matched to zipcodes obtained from the CMC mailing list. Various irregularities in the data, such as calculated yields above those biologically feasible, indicated that the data had not been verified. Therefore, each observation was examined and either accepted, modified (in one or two cases) or deleted.[1] This left 643 records and 7523 validated production events, an average of 11.7 per grower, approximately three quarters of the entire population.

Homogeneous Group Analysis

One of the standard approaches to the problem of adverse selection is to define classes of growers on the basis of their yield variability. This improves the precision of mapping between premium rates and the risks of production. As previously indicated, the typical practice in crop insurance ratemaking is to establish the risk level on a county basis using Statistical Reporting Service yield estimates. Since individual producer records were available for the cranberry industry, this study was not constrained to the use of county aggregates. Therefore, alternative divisions of the population were investigated in order to produce homogeneous rate classes. The precise number of classes was the result of balancing the following criteria:

(i) minimum membership in a rate class established as 25 growers

(ii) constancy of the coefficient of variation within the individual rate classes

(iii) minimization of the total number of rate classes

(iv) the smoothness of transition in premiums between rate classes.

Homogeneous groups were developed and analyzed utilizing the raw data described above. Since the rate premiums are calculated as a percentage of base yield, the coefficient of variation (standard deviation of yield per acre divided by mean yield per acre) was considered an attractive choice for selecting homogeneous risk classes. The coefficient of variation (CV) was calculated for each record (identification number) over the set of usable yields per acre. In order to test whether or not growers could be aggregated into homogeneous groups, the CV was regressed on mean acreage (A) and mean yield per acre (YPA) for each grower using ordinary least squares (OLS) procedures. The particular model used for testing whether or not individual growers could be aggregated into homogeneous groups was

$$CV = a + bA + cYPA. \quad (8)$$

Initially, individual growers were grouped into counties within Massachusetts (Barnstable, Bristol, Plymouth, and Other), regions within Wisconsin (Central, Northwest and North Central), and counties within Washington (Gray's Harbor and Pacific). New Jersey was retained as an aggregate due to its limited number of observations. In Oregon, approximately 90 percent of the growers were located in a single town.

The results of the estimation of equation (8) for the most disaggregate groupings and for various aggregations are shown in Tables 1 and 2. At this lowest level of aggregation, only in Massachusetts-Other, and West Central Wisconsin can the growers be regarded as homogeneous in the sense that CV does not vary significantly with yield per acre. In the other regions, CV decreases significantly with increasing yields. This implies that a number of yield classes need to be defined with a separate insurance premium for each. Since the number of growers in each class would be unacceptably small for some area-class combinations, the next step was to test whether or not these initial areas could be aggregated.

We performed an F test on equality of coefficients (commonly referred to as a Chow

[1] These modifications were made on the basis of guidelines provided by Delbert Rasmussen of the CMC and by cranberry experts (principally Dr. Irving Demoranville, Cranberry Experiment Station, Wareham, Massachusetts).

Table 1. Homogeneous Group Analysis: Eastern Producers

Unit	A	YPA	Constant	R square	SSR	n
Massachusetts	−.2526E-02	−.1824E-02	.6305	.169	13.77677	335
	(−2.2526)	(−7.8464)	(26.3714)			
Barnstable	−.7465E-03	−.2661E-02	.7481	.303	1.29840	40
	(−.4731)	(−3.2010)	(13.4135)			
Bristol	−.1488E-02	.2136E-02	.6783	.228	1.25312	34
	(−.7093)	(−2.6148)	(8.5445)			
Plymouth	−.2325E-03	−.1549E-02	.5891	.128	10.30322	254
	(−2.0674)	(−5.7330)	(20.5388)			
Other	−.7081E-03	−.1440E-02	.8188	.275	.30477	7
	(−.2452)	(−.9768)	(4.9247)			
New Jersey	−.3568E-03	.2625E-02	.6184	.411	.81855	39
	(−1.8583)	(−3.9273)	(15.0336)			
Massachusetts/ New Jersey	−.3098E-03	−.1784E-02	.6225	.178	3.19670	374
	(−3.1355)	(−8.3781)	(29.2273)			

Ratios of estimated coefficients to estimated standard errors are in parentheses.

test) for all the areas to determine whether it was possible to pool into larger aggregates. Results of the regressions on pooled data are also presented in Tables 1 and 2. Results of the pooling tests (available from the authors) showed that the hypothesis of coefficient equality was not rejected for any of the aggregates examined. Consequently, the conclusion of the analysis is that there are three homogeneous cranberry producing regions: (1) Massachusetts/New Jersey, (2) Wisconsin and (3) Washington/Oregon. Also of concern was whether or not grower records containing only a few observations displayed the same yield variation as complete records. Pooling tests on long and short data series showed that they could be grouped.

Since the estimated regression coefficients describing the effect of mean yields on the coefficient of variation were negative and almost always statistically significant, rate classes differentiated on the basis of yield levels were developed in order to avoid adverse selection. The individual regional homogeneous groups were disaggregated into 7 yield-based rate classes for Massachusetts/

Table 2. Homogeneous Group Analysis: Western and Midwestern Producers

Unit	A	YPA	Constant	R square	SSR	n
Wisconsin	−.5804E-03	−.1214E-02	.5699	.167	1.9812	103
	(−1.9153)	(−3.8272)	(12.9490)			
Central Wisconsin	−.7538E-03	−.1643E-02	.6372	.245	.5814	35
	(−1.4483)	(−2.9219)	(7.2882)			
Northwest and North Central Wisconsin	−.9106E-03	−.2610E-02	.7958	.374	.4253	23
	(−1.1366)	(−3.4532)	(6.8734)			
North Central Wisconsin	−.8521E-03	−.2982E-03	.4500	.117	.7677	45
	(−1.9762)	(−.6509)	(7.8167)			
Oregon	−.3572E-02	−.2100E-02	.6382	.283	1.7030	71
	(−1.6120)	(−4.6332)	(12.6485)			
Washington	−.2844E-03	−.1905E-02	.5784	.236	1.9955	95
	(−.2496)	(−5.3280)	(13.1429)			
Grays	−.7878E-03	−.2136E-02	.6268	.238	1.5412	67
	(−.1833)	(−4.2953)	(9.7253)			
Pacific	.1030E-03	−.2124E-02	.5488	.346	.3732	26
	(.1172)	(−3.4623)	(8.7621)			
Washington/ Oregon	−.9043E-03	−.2038E-02	.6018	.254	3.7501	166
	(−1.0073)	(−7.3803)	(18.4172)			

Ratios of estimated coefficients to estimated standard errors are in parentheses.

New Jersey, 5 for Wisconsin and 6 for Washington/Oregon. The specific classes that resulted from the balancing of the four criteria described earlier are displayed in Table 3.

Technical Change

When technical change occurs, yields per acre show an upward trend over time. Lower participation rates among eligible growers is a strong possibility if such change is not accommodated within the program. In addition, differential rates of technical change will result in adverse selection. Since approximately 31 percent of the growers had downward trending yields within the data period, this is not a trivial problem.

Three alternative approaches to adjust for technical change were examined for their theoretical and empirical implications for rate-making and performance. They were:

(i) no trend adjustment
(ii) uniform trend adjustment within a homogeneous group
(iii) individual grower trend adjustment.

The first approach is widely used in existing crop insurance programs. However, insurance agents are frequently instructed to use a moving average for the calculation of the appropriate contractual yield base. This is, in fact, a form of adjustment for trend. It should be noted, however, that the moving average yield base trails expected yield with the consequence that growers with upward trends will tend to opt out of the program.

The main virtue of the second approach is ease of application. One value can be supplied for each homogeneous group in order to bring each grower's moving average yield up to the yield expected with current technology. The cost of this ease is that each grower suffers a bias. Because the yield bases are biased, both premiums and payouts are higher than need be. The last approach requires the calculation of a yield trend for each individual grower. In this approach the yield base is individually adjusted to the production history captured in each grower's records. Clearly, this approach most directly confronts the problem of the accuracy of the premium structure that an individual faces. Therefore, we employed this method to detrend the individual grower records to represent a base 1982 productivity.

Table 3. Cranberry Insurance Premiums by Yield Class and Area

Homogeneous Group	Yield Range (barrels)	Guarantee level (percent of base yield) 50	65	75
Massachusetts/ New Jersey	0–40	0.0444	0.0751	0.1006
	41–55	0.0263	0.0445	0.0621
	56–71	0.0243	0.0519	0.0761
	72–95	0.0111	0.0222	0.0375
	96–116	0.0090	0.0128	0.0220
	117–160	0.0045	0.0068	0.0102
	161 & up	0.0019	0.0079	0.0186
Wisconsin	0–40	0.1613	0.2106	0.2325
	41–100	0.0455	0.0635	0.0813
	101–160	0.0054	0.0169	0.0310
	161–250	0.0016	0.0083	0.0200
	251 & up	0.0016	0.0094	0.0221
Washington/ Oregon	0–40	0.0584	0.0840	0.1078
	41–71	0.0376	0.0592	0.0800
	72–95	0.0249	0.0426	0.0645
	96–116	0.0199	0.0349	0.0504
	117–160	0.0075	0.0191	0.0345
	161 & up	0.0148	0.0239	0.0353

Estimation of Area Rate Premiums

Using equation (7) for each yield class, the fifteen year frequency of loss was taken as the estimate of the probability of loss. The average percent severity of those historical losses was used to estimate the magnitude of occurrence below the coverage level. The final set of pure premium rates are presented in Table 3. Insurance companies, in concert with FCIC, will load these premiums to cover underwriting expenses, including reinsurance. All premium rates, losses and revenues are in terms of barrels of cranberries. Crop insurance offered under the unloaded terms described in Table 3 would be most expensive for growers averaging less than 40 barrels per acre (which in the case of Wisconsin is a single grower). Premium rates within a geographic group decrease as yield increases until the last rate class when very high production levels are characterized by increases in yield variability, the insurers' measure of risk. As expected, premiums also increase with increases in the guarantee level. The increase in probability of loss (Table 4) as the guarantee level rises explains the behavior of premium rates within a yield class. These frequency increases are not directly translated into rate changes, however, due to the influence of the

Table 4. Probability of a Loss by Yield Class and Area

Homogeneous Group	Yield Range (barrels)	Guarantee level (percent of base yield) 50	65	75
Massachusetts/				
New Jersey	0–40	0.1365	0.2335	0.3022
	41–55	0.0810	0.1482	0.2114
	56–71	0.0810	0.1829	0.2801
	72–95	0.0317	0.0939	0.2134
	96–116	0.0173	0.0456	0.1558
	117–160	0.0098	0.0204	0.0571
	161 & up	0.0158	0.0666	0.1397
Wisconsin	0–40	0.3750	0.3750	0.3750
	41–100	0.0873	0.1518	0.2546
	101–160	0.0328	0.0848	0.1799
	161–250	0.0071	0.0721	0.1344
	251 & up	0.0126	0.0626	0.1387
Washington/				
Oregon	0–40	0.1334	0.2326	0.2981
	41–71	0.1045	0.1463	0.2625
	72–95	0.0677	0.1612	0.2585
	96–116	0.0652	0.1244	0.1838
	117–160	0.0316	0.0960	0.1829
	161 & up	0.0393	0.0817	0.1452

percent severity (Table 5). Aberrations in this pattern are the result of using an empirical frequency distribution for yields rather than a probability distribution.

Validation

It was noted earlier that the pure theoretical premium rate is defined as that value which makes aggregate premiums equal aggregate payouts from loss claims. It is this equality which has allowed us to focus upon the estimation of losses. A form of simulation, described below, should allow a final check on the validity of the estimated rate premiums by balancing total revenues and losses. It will also reveal the year to year variation in net receipts and payouts for insurers. Although some intertemporal variation will be tolerated by private insurers, these are usually the conditions under which they will seek reinsurance. Further, the FCIC in its oversight role has the capacity to revise premium rates if overall program performance is perceived to be poor. It is interesting to note that none of the theoretical ratemaking literature treats the problem of the differential temporal distribution of premium receipts and claim payouts. Rather, premium ratemaking is conducted in an interest free world.

Table 5. Percent Severity of Losses by Yield Class and Area

Homogeneous Group	Yield Range (barrels)	Guarantee level (percent of base yield) 50	65	75
Massachusetts/				
New Jersey	0–40	0.3255	0.3216	0.3317
	41–55	0.3249	0.3003	0.2937
	56–71	0.3004	0.2837	0.2717
	72–95	0.3512	0.2360	0.1757
	96–116	0.5213	0.2804	0.1414
	117–160	0.4611	0.3319	0.1790
	161 & up	0.1200	0.1186	0.1329
Wisconsin	0–40	0.4302	0.5617	0.6201
	41–100	0.5211	0.4185	0.3193
	101–160	0.1663	0.1989	0.1725
	161–250	0.2199	0.1156	0.1488
	251 & up	0.1279	0.1508	0.1590
Washington/				
Oregon	0–40	0.4381	0.3611	0.3618
	41–71	0.3598	0.4046	0.3048
	72–95	0.3677	0.2642	0.2494
	96–116	0.3054	0.2809	0.2744
	117–160	0.2370	0.1989	0.1889
	161 & up	0.3757	0.2929	0.2429

The ratio of losses and revenues can be computed for a premium structure under the stringent assumption of 100 percent grower participation. Recall that the premium rates presented in this paper do not include either administrative loading or the 30 percent subsidy authorized under the Federal Crop Insurance Act of 1980. Prediction of a grower's participation response requires knowledge of both production cost and the individual's risk preference, neither of which is currently available. Table 6 provides the undiscounted sums of premiums and payouts for the 1968–82 period by homogeneous area and guarantee level for the premium rates presented in Table 3. Again, these results are presented in units of barrels of cranberries. In each region, the ratio of the sum of losses to the sum of revenues is approximately equal to 1 as theoretically implied. The temporal distribution of losses and revenues as summarized by the annual ratio does not exhibit any consistent pattern across geographic areas. Wisconsin growers produce surplus revenues in the program for the first 9 years. However, outcomes in the other two regions are much more variable.

This simulation procedure can also be used to evaluate the implications of alternative rate structures for program performance. As noted, different weighting methods could be employed in rate premium calculation. Table 7

Table 6. Undiscounted Sums of Simulated Premiums and Payouts for 1968–82 at 65% Coverage

Homogeneous Group	Year	Losses	Revenues	Ratio
Massachusetts/ New Jersey	1968	10848.90	9763.20	1.11
	1969	12391.60	9718.00	1.28
	1970	2394.70	9679.10	0.25
	1971	714.40	9985.90	0.07
	1972	7220.20	9867.70	0.73
	1973	3395.80	9810.70	0.35
	1974	2776.40	9919.90	0.28
	1975	16038.00	9634.80	1.66
	1976	12129.50	10788.60	1.12
	1977	19376.40	10698.70	1.81
	1978	11637.60	10569.90	1.10
	1979	4866.20	10388.10	0.47
	1980	14008.00	10136.80	1.38
	1981	17897.00	9539.40	1.88
	1982	13874.00	9273.10	1.50
Wisconsin	1968	6527.20	7212.10	0.91
	1969	1385.90	7073.20	0.20
	1970	2224.00	6897.10	0.32
	1971	1644.80	6592.00	0.25
	1972	4913.90	7266.40	0.68
	1973	7058.40	7812.80	0.90
	1974	2059.50	7408.30	0.28
	1975	5026.00	8105.50	0.62
	1976	2070.00	8615.30	0.24
	1977	21385.20	8699.40	2.46
	1978	8314.20	8166.30	1.02
	1979	18608.30	8943.90	2.08
	1980	7491.60	7780.80	0.96
	1981	14491.30	4422.60	3.28
	1982	6451.80	4480.70	1.44
Washington/ Oregon	1968	1301.40	2261.00	0.58
	1969	5203.80	2349.40	2.21
	1970	876.50	2487.30	0.35
	1971	866.20	2664.70	0.33
	1972	161.90	2713.30	0.06
	1973	1580.00	2731.00	0.58
	1974	2512.30	2494.70	1.01
	1975	1207.50	2906.10	0.42
	1976	3005.90	3096.20	0.97
	1977	2524.60	3054.50	0.83
	1978	3245.80	3100.90	1.05
	1979	2293.90	3330.50	0.69
	1980	4155.10	3368.20	1.23
	1981	2408.90	3273.50	0.74
	1982	11446.50	2929.60	3.91

compares the outcomes of the production weighted rates with a grower based scheme. Note that losses are the same irrespective of how the premium is calculated. However, the grower based rate premiums are substantially higher than their production weighted counterparts. This results from the equal weighting

Table 7. Simulated Premiums and Payouts for Alternative Rate Premium Bases for 1968–82

Homogeneous Group	65% Level Production Weighting	65% Level Grower Based
Massachusetts/ New Jersey		
Losses	149568.7	149568.7
Revenues	149773.8	390452.3
Wisconsin		
Losses	109652.3	109652.3
Revenues	109476.5	138781.4
Washington/ Oregon		
Losses	42790.3	42790.3
Revenues	42760.9	45137.3

of low productivity but high risk operations with highly productive and stable firms. High risk cranberry enterprises consequently exert an undue influence on rate premiums. The aggregate result is loss to revenue ratios of .38, .79 and .95, respectively, for each of the geographic regions.

Conclusions

This paper has attempted to establish the reasons for a renewed interest in crop insurance. The expansion of traditional FCIC programs and the study of innovative proposals characterize the field (U.S. Department of Agriculture). Included among these proposals is the suggestion that neglected empirical frequency methods for calculating premium rates offer substantial promise for the estimation of actuarially sound rates when rich data sets are available. Examples of such opportunities include the proposed cranberry program discussed in this paper and the existing almond program established for California growers. As program development proceeds to less traditional crops and production regions, the potential for the application of this method in regional settings is high. In particular, the need for a generalized method is underscored by the impossibility of constructing completely homogeneous groups. Few commodities exhibit the homogeneity in firm acreage of some midwestern counties in the Corn Belt.

This paper also described some of the underlying theoretical issues in actuarially sound premium ratemaking. We discussed several alternative weighting schemes for the estimation of loss probabilities and illustrated the importance of the different choices. Substantive issues remaining include the problem of adjustment for technical change in rate calculation and necessary coordination with field techniques for estimation of the base yield for individual contracts. These guarantee levels are critical since they determine the trigger points for payouts. Little attention has been paid to the time distribution of both revenues and costs in crop insurance programs. Finally, given the interest in crop insurance as a risk management tool and component of the Farm Program, there is a need for analysis of representative grower response to program initiatives in order to predict participation rates. In short, crop insurance offers significant research opportunities for agricultural economists.

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