AN EVALUATION OF THE ACTUARIAL FAIRNESS OF THE YIELD EXCLUSION POLICY OPTION IN THE FEDERAL CROP INSURANCE PROGRAM

A Thesis

by

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ABSTRACT

This paper empirically evaluates the actuarial fairness of the Yield Exclusion policy option in the Federal Crop Insurance Program. The Yield Exclusion policy option was introduced in the 2014 Farm Bill, and allows producers to attain higher yield guarantees on FCIP crop insurance contracts through the elimination of low yields in their production history. This paper utilizes an empirical approach to calculate the extent to which premiums charged are excess of expected indemnities caused by applying Yield Exclusion to insurance policies. Premium-implied yield CDFs were derived, and used in the calculation these premium overcharges. These premium overcharges were then evaluated for five field crops, and evaluated on a geographic basis. In all, 438 insurance policies, varying by state, county, crop, crop type, and practice were utilized. It was determined that increases in premiums were in excess of the change in expected indemnities.

CONTRIBUTORS AND FUNDING SOURCES

Contributors

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NOMENCLATURE

RMA	US Department of Agriculture Risk Management Agency
FCIC	Federal Crop Insurance Agency
FCIP	Federal Crop Insurance Program
ADM	Actuarial Data Master
YE	Yield Exclusion
TA	Trend Adjustment
AIP	Approved Insurance Provider
SCCTP	State, county, crop, type, practice combination

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1. INTRODUCTION

The Federal Crop Insurance Program is increasingly the most important policy tool available to U.S. producers for risk management. Producers are able to insure against losses in yield, revenue, and gross margin on a variety of commodities and livestock. The program has seen expansion over the past thirty years, both in the number and types of contracts available to producers. As well, the number of policy options available to producers to apply to insurance contracts has increased. Statutorily mandated in the 2014 farm bill, the Yield Exclusion (YE) policy option allows producers to exclude particular yields from their Approved Yield calculations on certain crop insurance contracts. This policy option has the potential of increasing the amount of coverage a given producer can purchase, as well as affecting the probability of indemnification. The United States Department of Agriculture's Risk Management Agency compensates for this increased risk in indemnification by charging producers a higher premium for contracts with YE. The Federal Crop Insurance Program is mandated to charge premiums in a way that is actuarially fair, in that total premiums must cover total indemnities. As of now, no empirical studies have examined the effect of the YE option on the actuarial fairness of the crop insurance program. This paper utilizes an empirical methodology to evaluate the actuarial fairness of the Yield Exclusion policy option through an examination of premium overcharges caused by the election of Yield Exclusion. Premium overcharges occur when premiums are charged in excess of expected indemnities.

2. BACKGROUND

The Federal Crop Insurance Program has become one of the cornerstone policies of the agricultural safety net in the United States. The program allows producers of agricultural products in the United States to protect the value of their crop from declines in yield or market price. Conceived in 1938, and granted permanent authorization at that time, the program has undergone several enlargements (Kramer, 1983). The most prominent of which occurred with the passing in 1980 of the Federal Crop Insurance Act. Further expansion of subsidies, coverage levels and policies occurred through the mid 1990s and early 2000s (Shields, 2015). The program is administered by the USDA's Federal Crop Insurance Corporation, and it's subsidiary agency, the Risk Management Agency. The program currently operates as a public private partnership, with rates and policies being set by the RMA, and policies being sold and serviced by private industry insurers, referred to as Approved Insurance Partners (Rosch, 2021). The Federal Government provides subsidies to the program in two ways. Firstly, the Federal Government subsidizes a portion of the producer paid premiums, and secondly a portion of AIP's operating and administrative costs are subsidized (Rosch, 2022b). The program has seen growing participation since its inception. As of 2021 the number of acres, and the value of all livestock and crops insured has hit all time highs, with more than 444 million acres insured, and over $150 billion in total liability (Rosch, 2022a).

Currently, insurance contracts can be purchased that insure against decreases in the yield that producers can expect, decreases in revenue, caused by either yield decreases or commodity price movements. As well, area, rainfall, and whole farm revenue based contracts are offered (Rosch, 2021). As of 2014 the most commonly purchased policies are those that cover against declines in revenue, with 77% of policies falling under this category (Shields, 2015). The remaining 23% are yield based contracts. Producers can insure a wide variety of crops and livestock, and can insure acreage being grown under several best-management practices. The availability of coverage for any crop or management practice is decided by the RMA on a county by county basis. Producers may decide on the unit structure that they insure. Units allow for producers to insure different subdivisions of an operation under a single plan. They are primarily used to account for differences in ownership and leasing practices across producers (Rosch, 2021). Producers may insure under basic, optional, enterprise, multi-county enterprise, or whole farm units, subject to various constraints.

The RMA sets the rating criteria for premiums for all policies sold under the program. Rates are set so that total, un-subsidised, premiums paid into the program are equal to the amount paid out to producers in indemnities. This is to ensure that on the whole the program is actuarially fair. The RMA achieves this through a historical loss-cost rating methodology. Rates are based off of historical loss data, and set so that the loss ratio, which is the amount of premiums received over the amount of indemnities paid for the program, is equal to or above 1 (Rosch, 2021). Crop prices for the rating process are mostly retrieved from the Chicago Board of Trade futures market. These are used to determine the value of yield guarantees in dollar terms, and for the value of revenue guarantees. Rates are individualized to the experience of the producer through the use of an Actual Production History. This is used to calculate a Rate Yield which is approximately the average of ten years of yields for a given producer, growing a given crop (Shields, 2015). Rates are adjusted by how risky this production history is relative to other producers of the same crop in the same county, using the same production practices. This is accomplished by comparing a given producer's Approved Yield to the county average yield. Producers with Rate Yields above their county average pay lower premiums, and those with lower Rate Yields pay higher premiums. Since 2010, several policies have been introduced that allow producers to adjust their Approved Yield, which reflects various possible adjustments from the level of the Rate Yield, and is used to calculate indemnities.The most prominent of these two are Trend Adjustment and Yield Exclusion. Trend Adjustment allows for producers to adjust past yield upwards for a crop that has experience an overall increasing yield year after year (USDA, 2020). This allows producers to attain higher Approved Yields.

Yield Exclusion, which is the focus of this paper, allows producers to remove specific yields from their production history. Added to the program in the 2014 Farm Bill, this policy option allows producers to remove yields from the calculation of their Approved Yield from years in which the county average yield falls below 50% (Witt, 2014). This allows producers the potential to attain Approved Yields that are otherwise higher than would be calculated. YE was first available for the 2015 crop year. In that first year $8,655,717,579 worth of liability out of a total of $40,092,318,536 was insured under policies with YE (USDA, 2016). No publicly available figures for subsequent years have been published on the number of contracts with YE. To compensate for the increases in indemnification from higher yield guarantees attained with YE, the RMA adjusts the premiums charged for policies with YE upward (USDA, 2015). This is done to ensure that the Yield Exclusion Policy option is actuarially fair. This paper seeks to evaluate empirically the actuarial fairness of the Yield Exclusion option.

3. LITERATURE REVIEW

A small body of literature surrounds the Federal Crop Insurance Program Yield Exclusion policy option. The Risk Management Agency commissioned a review of the implementation of the rating mechanism for YE. The initial review was completed by Sumaria Systems, with subsequent comments from a set of five outside reviewers. These reports focused on the implementation of the YE rating methodology, and the adequacy of that methodology in light of the existing methodology (Knight et al., 2015). Theses reports were generally supportive of the RMA's proposed rating methodology, however did make recommendations on evaluating the proposed interpolation and extrapolation mechanisms utilized in rating the coverage levels attained through the use of YE (Witt, 2014). Adhikari and Luitel (2016) compare the effects that YE and Yield Substitution have on producer welfare. They find that on net, and for cases where YE causes a large increase in a producer's Approved Yield, YE contracts yield higher producer welfare (Adhikari and Luitel, 2016). As well, Luitel examined the optimal cotton producer's insurance choices under the provisions in the 2014 farm bill, finding that the optimal level of coverage is 75%, regardless of election of YE (Luitel, 2016).

A larger body of literature surrounds the evaluation of the actuarial fairness and rating accuracy of the Federal Crop Insurance Program as a whole. Babcock et al. examine the actuarial fairness of constant rate relativities and find that constant rate relativities are inconsistent with actuarial fairness (Babcock et al., 2004). Woodard et al. examine the actuarial fairness of the RMA's loss-cost ratio rating methodology (Woodard et al., 2011). They find that the LCR rating methodology overestimates rates for Illinois corn by a range of 75% to 180%, and do not account for changes in average yield over time. Maisashvili et al. develop a methodology for deriving upper and lower bounds for yield cumulative distribution functions implied by crop insurance premiums. They find that the premium implied CDFs violate the laws of probability for around 40 million acres insured in the program (Maisashvili et al., 2019). Price et al. derive a methodology for evaluating the actuarial fairness of the crop insurance program by comparing the crop yield density functions inferred from premiums to those inferred from yield data. They apply this methodology to 2009 crop insurance data from Iowa, finding that rates are too high for high productivity land, and too low for low productivity land (Price et al., 2019). Chen et al. evaluate the geographic scale and fiscal implications of misratings in the FCIP. They find significant geographic auto-correlation in misratings amongst counties, and find that roughly 40% of all counties are misrated.

There are currently no empirical studies on the actuarial fairness of the Yield Exclusion policy option in the published literature. This paper seeks to fill that gap.

4. METHODOLOGY

This paper motivates an empirical methodology to evaluate the actuarial fairness of the Yield Exclusion policy option through a an examination of the premium overcharges. The analysis here is performed under the assumption that non-YE premiums are calibrated to be actuarial fair. That is, total premiums are charged that are equal to expected indemnities. Premium overcharges occur when premiums are charged in excess of the expected indemnities for an insurance contract. A methodology is motivated here for calculating premium overcharges utilizing premium implied yield distributions. These overcharges are calculated for valid counties in the United States for five major field crops: corn, cotton, wheat, soybeans, and grain sorghum, hereafter sorghum. These premium overcharges are evaluated on a per crop and geographic basis. This allows for an examination of the effect of Yield Exclusion on the actuarial fairness of premiums charged, and on the actuarial fairness of the crop insurance program.

The following subsections detail the process of deriving the premium overcharges. Section 4.1 details the data utilized in the calculation of premiums and indemnities. Section 4.2 summarizes the RMA's process for the calculation of premiums for policies both with, and without YE. As well, this section describes the process by which premium schedules for successively larger coverage levels are calculated. The premium schedules are used in the derivation of implied crop yield cumulative distribution functions. Section 4.3 sets forth this process. These CDFs are then used in the calculation of expected premiums. Section 4.4 details how premium overcharges are calculated utilizing the partial yield CDFs derived in section 4.3.

4.1 Data Source

Data for the calculations of premiums and production guarantees comes from the RMA's Actuarial Data Master(ADM) (USDA, 2022). The RMA publishes this data regularly and is used in the calculation of premiums by AIPs. As detailed below, representative producer production histories are synthesized for each state, county, crop, type, practice combination evaluated. The data used to synthesize these production histories was retrieved from the RMA's ADM. County average yields are used as the basis of these production histories. These average yields are the simple trailing 10 year average of crop yields for a given state, crop, county, type, practice combination.

4.2 Premium Schedule Calculations

The calculation of premiums is done in accordance with RMA instructions, which are summarized here (USDA, 2021). In setting rates for individual producers, the RMA conditions a county target rate upon individual producer's production histories and policy elections to determine any given producer's rate. The determination of county target rates is described in Coble et al. (2010), as being decomposed into two additive components, a variable rate component and a fixed rate component. The fixed rate component accounts for geographic variations in re-plantings, prevented plantings, quality adjustments, and state-wide catastrophic claims (realized yields under 50% of the 10 year simple average of yields). The variable rate component accounts for the county wide historical loss experience, county catastrophic claims, and an adjustment based on a disaster reserve factor. Both the fixed and variable portions of the rate are conditioned on a Unit Division factor. This factor accounts for differences in unit structure selection.

The county target rate is then individualized to the producer level through the use of the yield ratio, an exponentiation factor, a type-practice factor, and the coverage level differentiation:

$$
\begin{aligned}
IndividualTargetRate = ((Y_{Rate}/Y_{ref})^{-E} * VariableRate + TPFactor) \\
+ (FixedRate)) * (CoverageLevelDifferential). \quad (4.1)
\end{aligned}
$$

In Equation 4.1, the yield ratio, (Y_{Rate}/Y_{ref}), and exponential factor, E, are used to account for heterogeneous risk at the individual insured unit level. The yield ratio is the producer's Rate Yield divided by a 10-year county average of crop yields retrieved from the National Agricultural Statistics Service. The exponential factor is negative. Together these adjust premium rates to be higher when the producer's average is lower than the county average, and lower when the producer's average yields are higher. The $TPFactor$ accounts for differences in risk profile amongst approved production techniques and crop types. The $CoverageLevelDifferential$ accounts for the increased likelihood of indemnification caused by producers self-selecting into higher coverage levels. Higher coverage levels have a lower deductible, which is the distance between the approved yield and the selected coverage level. The $CoverageLevelDifferential$, hereafter CLD, adjusts premiums upwards to account for this lower deductible. The CLD is determined through a median regression, with a combination of coverage level and the county target rate as independent variables (Coble et al., 2010).

Policy options such as TA and YE allow producers to adjust their Approved Yield upward from the level of the Rate Yield to achieve higher levels of coverage. The RMA rating methodology aims to charge the same premium for the same coverage guarantee regardless of how the coverage guarantee is calculated (USDA, 2015). As in the case of self-selected higher coverage levels, higher coverage levels attained through the adjustment of Approved Yields have premiums increased to account for higher expected indemnities. This adjustment in premiums is done through the calculation of an effective coverage level. This effective coverage level is calculated as following (Knight et al., 2015):

$$EffCL = (NomCL) * (YE_{Approved}/SA_{Approved}) \tag{4.2}$$

Where in Equation 4.2 $EffCL$ is the effective coverage level, $NomCl$ is the producer selected coverage level, $YE_{Approved}$ is the Approved Yield after the application of yield exclusion, and $SA_{Approved}$ is the simple average Approved Yield. This effective coverage level is treated as though it were a coverage level selection, and a CLD is applied to the producers premium rate. Producers may select coverage levels between 50% to 85% coverage in 5% increments. As Effective Coverage Levels can fall between the approved coverage level increments of 5%, the RMA uses a linear interpolation to determine CLDs for Effective Coverage Levels that fall between the 5% increments. If the election of YE causes an Effective Coverage Level above the 85% coverage level, then a CLD is determined based off of a linear extrapolation of the rate of change in the

CLDs over the highest two nominal coverage levels (Knight et al., 2015). As of the 2016 crop year, the RMA also adjusts rates by a 5% uncertainty factor that is phased in over the 85% to 100% Effective coverage Level Range.

Utilizing the above formula for individual rate setting, premium schedules for a representative producer are calculated for all valid county-crop combinations for four major field crops. The premiums are calculated for Yield Protection policies, with optional units as the unit structure and non-irrigated practices. Premium schedules include premiums calculated for the 5% coverage increments across the 50% through 85% coverage level space. The four major field crops being investigated are corn, soybeans, wheat, and short staple cotton. Total premium for a producer is calculated from the individual target rate, the projected price at harvest, the insured's Approved Yield, and the insured choice of coverage level:

$$P_c = P_{proj} * IndividualTargetRate * Y_{Approved} * c \tag{4.3}$$

In Equation 4.3 P_c is the total premium for coverage level c, P_{proj} is the projected price, and $Y_{Approved}$ is the producer's approved yield. For the above calculations, all values other than the $SA_{Approved}$ and coverage level c are retrieved from the RMA's Actuarial Data Master. These premium schedules are used to derive premium implied yield distributions used in the calculation of expected indemnities.

4.3 Crop Yield Cumulative Distribution Functions

The calculation of premium overcharges requires the specification of underlying probability distributions for crop yields. The derivation of these premium-implied crop yield CDFs is done under the assumption that Yield Protection premiums (before YE adjustments) are actuarially fair. The methodology for deriving premium-implied upper and lower bounds for cumulative distribution functions developed in Maishasvilli et al. (2019) is employed. This method is used to calculate upper and lower bounds of yield CDFs through the use of changes in total producer premiums from the selection of successively higher coverage levels. The upper bound of the yield

CDFs are calculated as thus:

$$F(Y_{c+\delta}) \geq \frac{\Delta P_{c \to c+\delta}}{Y_{c+\delta} - Y_c} \tag{4.4}$$

and the lower bounds are:

$$F(Y_c) \leq \frac{\Delta P_{c \to c+\delta}}{Y_{c+\delta} - Y_c} \tag{4.5}$$

In Equation 4.4, and Equation 4.5 the value of the yield CDF at indemnity triggering yields Y_c and $Y_{c+\delta}$, are bounded by the change in premiums, $\Delta P_{c \to c+\delta}$ over the difference in yields, $Y_{c+\delta} - Y_c$. Y_c and $Y_{c+\delta}$ are the yield at a given coverage level c, and the next successive coverage level $c + \delta$. To infer underlying yield CDFs from the upper and lower bounds, a cubic smoothing spline is first be fit to the premium schedules for each of the four major field crops. Figure 4.1 illustrates this cubic smoothing spline, as well as the premium schedule for coverage levels 50 through 85:

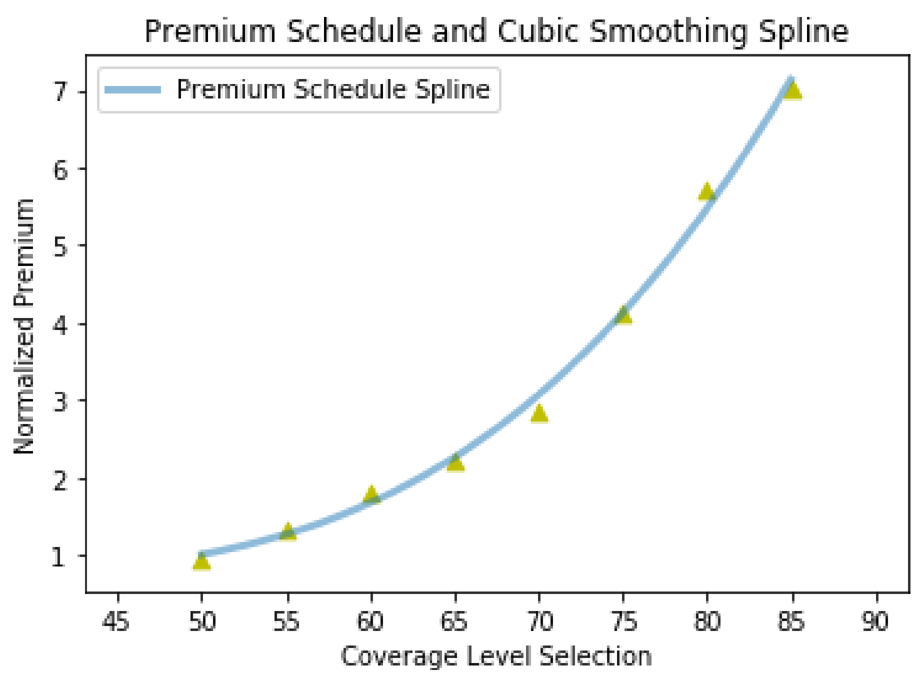

Figure 4.1: Premium Schedule and Cubic Smoothing Spline

The values in Figure 1 are from a representative set of premiums calculated for non-irrigated winter wheat in Sandusky county, Ohio, for the 2022 crop year. This spline creates a interpolated and continuous premium schedule between the discrete coverage level elections. From this continuous premium schedule, the above upper and lower yield CDF bounds collapse together, as the differences in yield coverage levels can be evaluated at smaller increments. Figure 4.2 illustrates graphically this premium implied partial CDF for the Sandusky Ohio case:

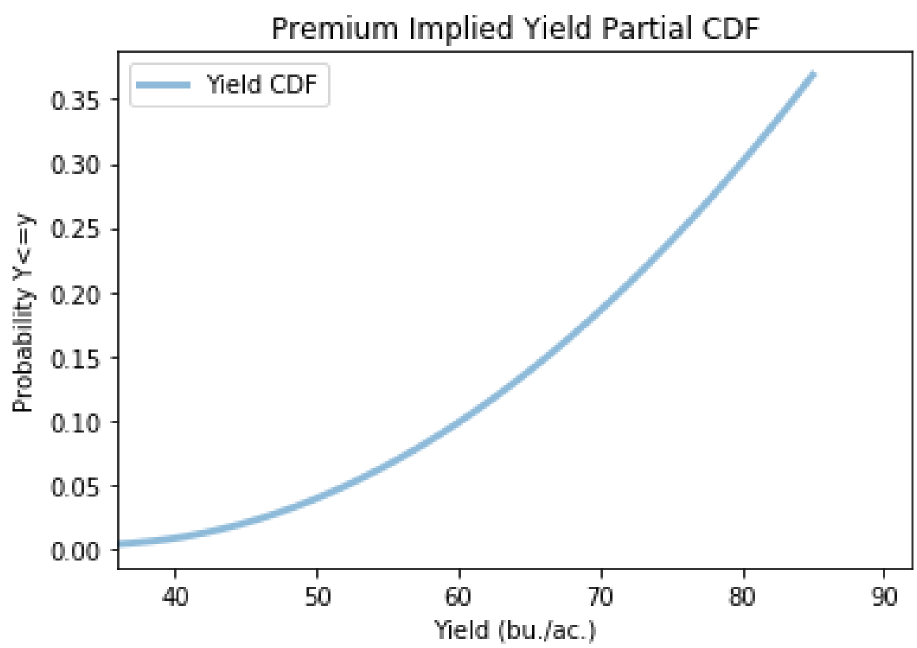

Figure 4.2: Premium Implied Yield Partial CDF

The use of premium implied CDFs allows for the specification of yield distributions that align with indemnity thresholds, and that do not require any additional assumptions of skewness or general form (Maisashvili et al., 2019).

4.4 Calculation of Lower Bounds of Premium Over-Charge from the Election of Yield Exclusion

The lower bounds of premium overcharges are calculated utilizing the above premium implied yield cumulative distribution functions. Premium overcharges occur when premiums are charged in excess of expected indemnities:

$$Overcharge = (P_{c+\delta} - P_c) - (E(indem)_{c+\delta} - E(indem)_c) \tag{4.6}$$

In equation 4.6, $Overcharge$ is the premium overcharge, and the first term, $P_{c+\delta} - P_c$ is the change in premium from moving from coverage level c to $c+\delta$. The second term, $E(indem)_{c+\delta} - E(indem)_c$, is the difference in expected indemnity $E(indem)$, caused from moving from coverage level c to $c + \delta$. Both the change in premiums, and the change in expected indemnities are calculated on a normalized basis. Expected indemnities are calculated under the assumption that it is know in advance that the yield realized by a producer under a given crop insurance contract is below the indemnifying yield guarantee. Under this assumption, the change in normalized expected indemnity caused by the election of YE is simply the difference between the two yield guarantees:

$$\Delta ExpectedIndemnity = Y_{ye,i} - Y_{r,i} \tag{4.7}$$

In equation 4.7, $Y_{ye,i}$ is the yield guarantee after the election of yield exclusion for a valid SCCTP combination i, and $Y_{r,i}$ is the yield guarantee before the election of yield exclusion for a valid SCCTP combination i. Maishavili et al. find that for certain SCCTP combinations the premium implied yield distributions exceed probabilities of 1. Selecting for these miss-specified premium implied CDFs allows for the incorporation of the above assumption into the analysis.

The change in normalized premium caused by the moving from one level of coverage to another can be calculated as the area under the premium implied yield CDF between those coverage levels Maisashvili et al. (2019):

$$\Delta P_{norm} = \int_{Y_c}^{Y_c+\delta} F_{p.i.}(Y)\, dY \tag{4.8}$$

In equation 4.8, P_{norm} is normalized premium,$F_{p.i.}$ is a premium-implied yield CDF, Y_c is the yield guarantee for coverage level c, and $Y_{c+\delta}$ is yield guarantee for coverage level $c + \delta$. Incorporating the assumptions stated above, and utilizing equation 4.8, the premium overcharge for yield exclusion can thus be calculated as:

$$Overcharge = \int_{Y_c}^{Y_{c+\delta}} (F_{p.i.}(Y) - 1)dY \tag{4.9}$$

In equation 4.9, the premium overcharge from the election of YE is calculated as definite integral of the premium implied yield CDF, less one, integrated across the bound of the original coverage level Y_c, to the coverage level after the application of YE $Y_{c+\delta}$. This integral is calculated for all valid SCCTP combinations with premium implied CDFs that are miss-specified for the crop insurance year 2022, for the major field crops of corn, cotton, wheat, grain sorghum, hereafter sorghum, and soybeans. The geographic distribution, and economic impact, of these premium overcharges are explored through summary statistics and map plots.

5. RESULTS

5.1 Summary Statistics

The lower bounds of premium overcharges, hereafter premium overcharges, were calculated for a total 438 state, county, crop, type, and practice combinations,for the 2022 crop year. These were SCCTP combinations where the election of YE had a material effect on the producers Approved Yield, increasing the amount of coverage the producer could purchase. Approved Yields were calculated in accordance to RMA rules and procedures for both the base case without YE, and with YE applied. A 10 year synthetic producer history was derived for each SCCTP combination. Each yield in the synthetic producer history was derived from the simple 10 year average of county yields for that given crop year in that given county. Years that are eligible for YE were then retrieved from the RMA ADM, and were subsequently dropped from the calculation of the Approved Yield. Table 5.1 details the summary statistics for change in Approved Yield in percentage terms for all SCCTP combinations, broken down by crop:

	N	Low	High	Q1	Q2	Q3	Mean	Mode	STD
Corn	67	0.00	12.00	3.00	5.00	6.00	5.27	5.00	2.53
Wheat	163	0.00	10.00	0.00	1.00	2.00	1.30	1.00	1.99
Sorghum	43	0.00	3.00	1.00	1.00	2.00	1.14	1.00	0.80
Soybeans	42	0.00	2.00	1.00	1.00	1.00	1.05	1.00	0.54
Cotton	123	1.00	80.00	10.50	23.00	44.50	30.07	6.00	22.77

Table 5.1: Summary statistics for change in approved yield, in percent change.

Of the 438 SCCTP combinations evaluated, wheat has the largest number of observations with 163, followed by cotton with 123 and corn with 67 observations. Sorghum and Soybeans follow with 43, and 42 observations respectively. The values in Table 5.1 are denominated in their respective yield per acre units. Corn, wheat, sorghum, and soybeans are denominated in bushels per acre, while cotton is denominated in pounds per acre. Due to this, mean, mode, and quartile values are not comparable across crops. Standard deviation values, however, can be compared across crops. Cotton sees the highest variance in changes in approved yield, with a standard deviation of 22.77. Corn sees the second largest variance, with a standard deviation of 2.53. Soybeans sees the smallest variation of changes in approved yield.

The increase in approved yield caused by the election of YE causes an increase in the premium paid by producers. Premiums are normalized, in that they are reported on a per dollar of liability basis. Summary statistics for the change in normalized premium associated with each increased approved yield are presented in Table 5.2:

	N	Low	High	Q1	Q2	Q3	Mean	Mode	STD
All Crops	438	0.00	78.47	0.82	1.71	8.08	10.06	0.00	18.07
Corn	67	1.62	10.51	3.13	4.75	6.14	4.93	2.55	2.29
Wheat	163	0.00	9.30	0.00	0.84	1.62	1.21	0.00	1.76
Sorghum	43	0.00	2.55	0.81	0.85	1.62	0.99	0.00	0.67
Soybeans	42	0.41	1.81	0.81	0.82	0.85	0.95	0.82	0.39
Cotton	123	1.00	78.47	8.98	25.37	52.32	30.86	6.64	23.46

Table 5.2: Summary statistics for change in normalized premium for all crops.

As premiums are calculated on a normalized basis, a proper comparison across all five crops examined here is possible. Aggregating the values of all crops, it can be seen that the mean increase in normalized premium is 10.06. Cotton sees the highest mean increase in normalized premium with an increase of 30.86. All other crops see a mean increase bellow the all crops case. As well, cotton sees the most variation in the change in premium, and soybeans sees the least.

Premium overcharges are calculated utilizing Equation 4.9. Table 5.3 details the summary statistics for premium overcharge for the five separate field crops examined here, as well as the all crop case:

	N	Low	High	Q1	Q2	Q3	Mean	Mode	STD
All Crops	438	0.00	28.30	0.02	0.18	0.74	2.10	0.00	5.21
Corn	67	0.00	3.70	0.21	0.52	0.98	0.72	0.14	0.73
Wheat	163	0.00	1.30	0.00	0.05	0.23	0.17	0.00	0.27
Sorghum	43	0.00	0.51	0.01	0.03	0.11	0.08	0.00	0.12
Soybeans	42	0.00	0.54	0.02	0.04	0.10	0.11	0.02	0.16
Cotton	123	0.01	28.30	0.43	2.15	12.49	6.80	0.04	8.10

Table 5.3: Summary statistics for lower bound of premium over-charge.

The largest premium overcharge was calculated for cotton, with an overcharge of 28.30 in normalized premium terms. This is followed by corn, with 3.70, wheat with 1.30, soybeans with 0.54, and sorghum with 0.54. Cotton and corn show the highest variation in premium overcharges. The mean values for each of the crop cases, as well as the aggregated all crop case, are larger than the median values. This indicates that the distribution of premium overcharges for each of the cases is skewed towards larger values of premium overcharge.

From Table 5.2 and Table 5.3, it can be seen that the distributions, and general structure of the data for changes in premiums and premium overcharges are similar. Figure 5.1 illustrates this relationship:

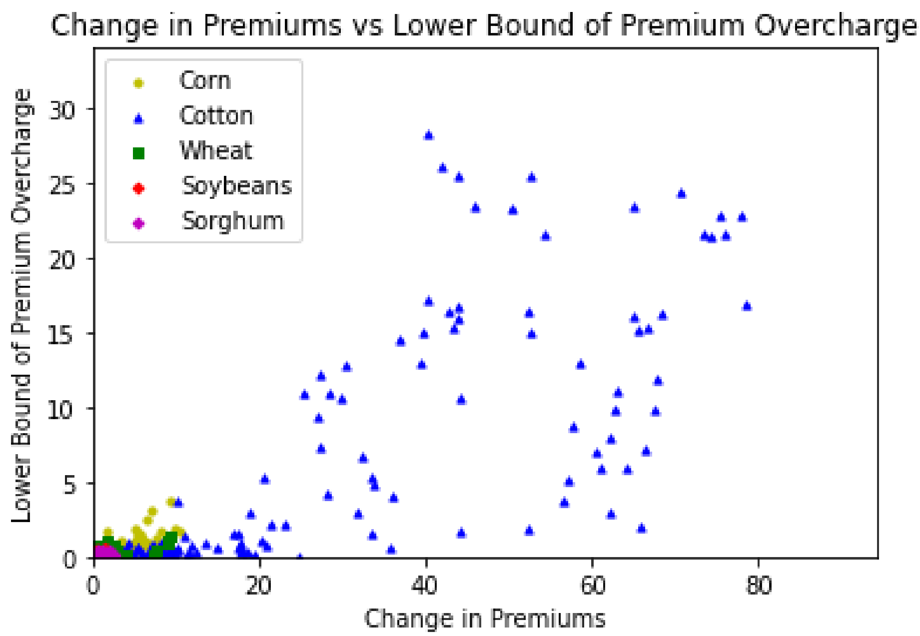

Figure 5.1: Change in premium versus lower bound of premium overcharge.

Figure 5.1 plots the change in premiums against the lower bound of premium overcharges for all five field crops. This figure is illustrative of the several aspects of the above tables, including the larger changes in premium, premium overcharge and greater dispersion in the cotton data when compared to the other four field crops examined here. As well, Figure 5.1 illustrates a linear relationship between the change in premium, and thus the underlying change in approved yields, and premium overcharges. In the above figure, larger changes in premiums are generally more likely to be accompanied with larger premium overcharges. This relationship holds for all of the crops examined, but is most apparent in the cotton data .

5.2 Geographic Distribution of Premium Over-Charges

Examining the geographic distribution of the premium overcharges across the United States shows that there are regional disparities in premium overcharges. The 438 premium overcharges examined in this paper were calculated for SCCTP combinations across the United States. In the aggregate, all crop case, premium overcharges were calculated for SCCTP combinations in 24 separate states. The number of premium overcharges calculated for each state varies. The state with the largest number of premium overcharges is Texas, with 209, and the fewest in the states of Montana, South Dakota, Ohio, Nebraska, and Washington each with one SCCTP. Table 5.4 details the summary statistics for premium overcharges by state, for the six states with the largest numbers of premium overcharges:

	N	Low	High	Q1	Q2	Q3	Mean	Mode	STD
Texas	209	0.00	25.37	0.00	0.14	0.61	2.15	0.00	5.20
Oklahoma	52	0.00	28.30	0.05	0.42	4.09	4.04	0.05	7.29
Georgia	29	0.00	1.73	0.02	0.09	0.29	0.22	0.02	0.35
Kansas	27	0.00	24.29	0.07	0.20	5.35	5.28	0.08	8.90
Arkansas	16	0.00	11.83	0.03	0.08	1.16	1.29	0.01	2.99
New Mexico	12	0.00	0.63	0.01	0.08	0.53	0.23	0.00	0.27

Table 5.4: Premium overcharges by state, for all crops.

As stated above, Texas has the largest number of premium overcharges calculated for the five field crops examined here. This is followed by Oklahoma, Georgia, Kansas, Arkansas, and New Mexico. In the top six states, the highest value of premium overcharge was in Oklahoma, with an overcharge of 28.30. Mean values of premium overcharge vary from a high of 5.28 in Kansas, to a low of 0.22 in Georgia. The states in the top six are geographically from either the south or the west. As well, and with the exceptions of Georgia and Arkansas, the states listed here all encounter growing conditions that could be classified as dry land.

The geographic distribution of premium overcharges by each of the five major field crops is examined here. Each of the subsequent tables gives the summary statistics of six states with the most number of premium overcharges for each of the respective crops. Table 5.5 details the summary statistics for the premium overcharges for corn:

	N	Low	High	Q1	Q2	Q3	Mean	Mode	STD
Georgia	11	0.09	1.73	0.14	0.28	0.51	0.42	0.09	0.48
Oklahoma	9	0.03	3.11	0.14	0.84	0.98	0.97	0.03	1.10
Alabama	8	0.27	1.47	0.34	0.69	0.88	0.73	0.27	0.44
Kansas	6	0.08	1.04	0.16	0.31	0.67	0.44	0.08	0.38
Michigan	6	0.63	1.16	0.67	0.86	1.08	0.88	0.63	0.24
Mississippi	6	0.00	0.85	0.08	0.47	0.72	0.42	0.00	0.38

Table 5.5: Premium overcharges for top six states for corn.

The geographic distribution of the corn premium overcharges varies from that of the all state case. In contrast to the all crop case the top six states by number of overcharges are Georgia, Oklahoma, Alabama, Kansas, Michigan, and Mississippi. As well, the mean values of premium overcharge are much lower in all six of the top states for corn, compared to the top six states in the all crop cases. Figure 5.2 shows the geographic dispersion of premium overcharges for corn on a map of the contiguous united states:

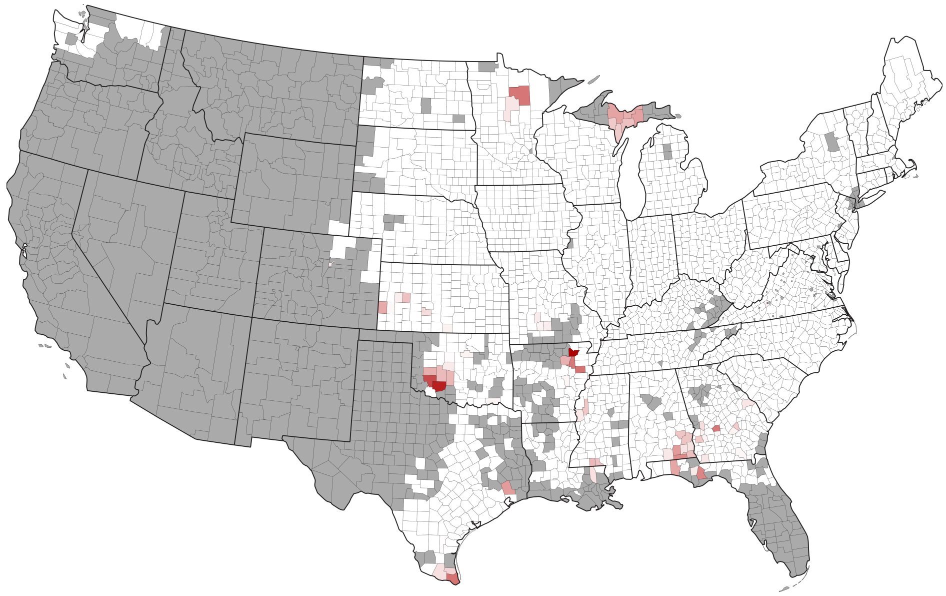

Figure 5.2: Geographical distribution of corn premium overcharges.

In figure 5.2, the darker red a given county is, the larger the premium overcharge is after the election of YE. Counties in white are valid for a SCCTP combination, but experience no premium overcharge. The counties in grey are those where a given crop or practice are not valid, and thus insurance cannot be purchased in those counties for a given SCCTP. In the case of corn, we find that for the 2022 crop year premium overcharges are clustered around certain regions. Overcharges appear prominently in Oklahoma, as well as in the Upper Peninsula of Michigan, the Rio Grande valley in Texas as well as in Southeastern Alabama and Northwest Florida.

The summary statistics of six states with the most number of premium overcharges for wheat is presented in Table 5.6:

	N	Low	High	Q1	Q2	Q3	Mean	Mode	STD
Texas	89	0.00	0.82	0.00	0.00	0.19	0.12	0.00	0.20
Oklahoma	15	0.00	0.66	0.02	0.05	0.16	0.13	0.00	0.19
California	11	0.05	1.30	0.34	0.48	1.06	0.67	1.30	0.46
New Mexico	8	0.00	0.63	0.00	0.14	0.60	0.27	0.00	0.30
Kansas	8	0.00	0.58	0.02	0.07	0.20	0.17	0.00	0.23
Virginia	4	0.02	0.06	0.02	0.03	0.04	0.03	0.02	0.02

Table 5.6: Premium overcharges for top six states for wheat.

Figure 5.3 shows the geographic dispersion of premium overcharges for wheat on a map of the contiguous united states, using the same schema as figure 5.2:

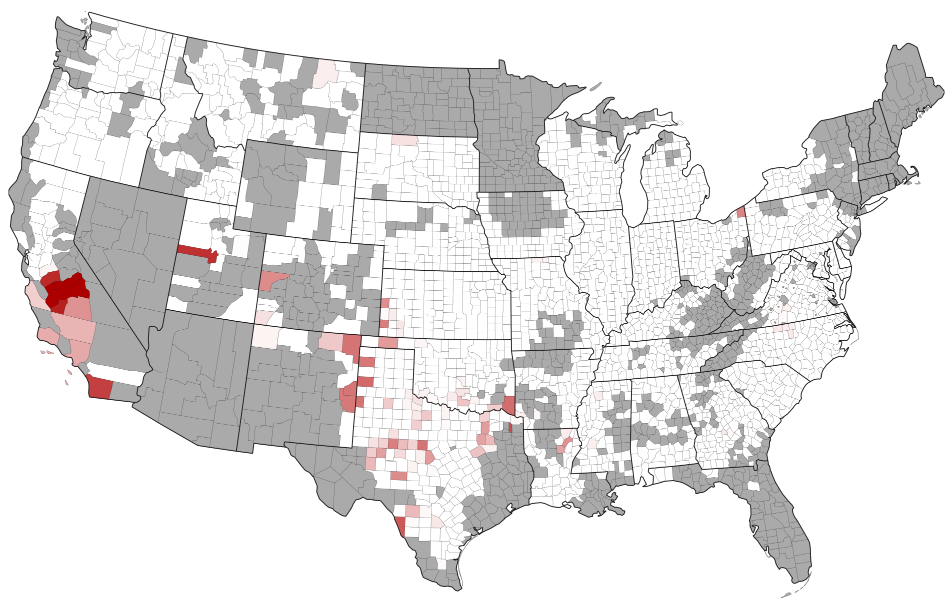

Figure 5.3: Geographical distribution of wheat premium overcharges.

From Table 5.6 and Figure 5.3, we see that wheat varies more significantly from the all crop case than does corn in terms of geographic distribution of premium overcharges. Of note is the significant amount of premium overcharge for SCCTP combinations in California. As well, the majority of SCCTP combination for which a premium overcharge could be calculated were located west of the Mississippi. For wheat, the top six states experienced very similar mean increases in premium overcharge, as well as similar standard deviations.

Table 5.7 details the summary statistics of six states with the most number of premium overcharges soybeans:

	N	Low	High	Q1	Q2	Q3	Mean	Mode	STD
Georgia	14	0.00	0.51	0.02	0.02	0.05	0.12	0.02	0.19
Texas	8	0.02	0.51	0.02	0.06	0.12	0.12	0.02	0.17
Oklahoma	6	0.00	0.05	0.02	0.04	0.05	0.03	0.04	0.02
South Carolina	4	0.04	0.54	0.04	0.12	0.29	0.21	0.04	0.24
Arkansas	3	0.00	0.02	0.01	0.01	0.01	0.01	0.00	0.01
Florida	2	0.01	0.41	0.11	0.21	0.31	0.21	0.01	0.28

Table 5.7: Premium overcharges for top six states for soybeans.

Figure 5.5 projects the geographic distribution of premium overcharges for wheat onto a map of the contiguous United States:

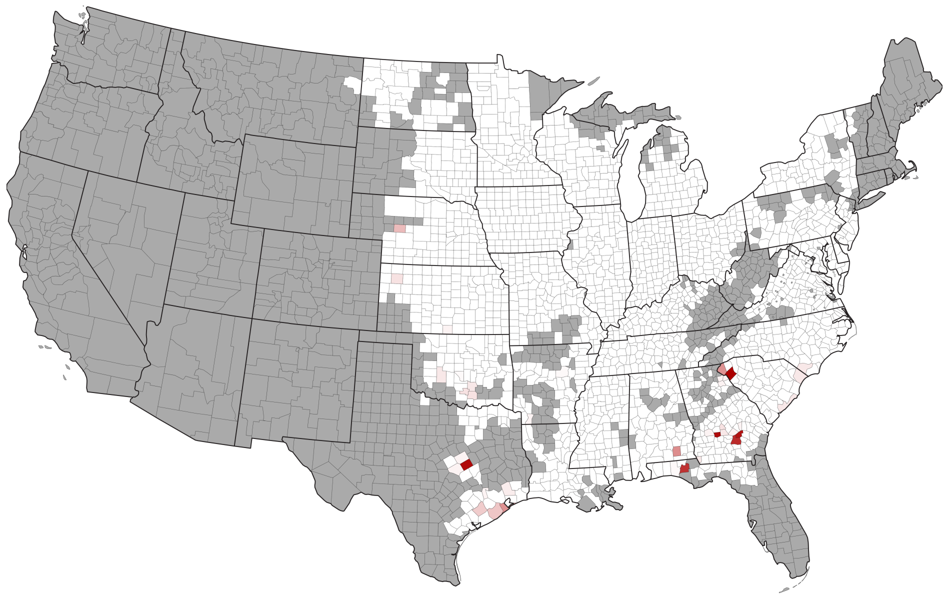

Figure 5.4: Geographical distribution of soybean premium overcharges.

Table 5.8 shows the summary statistics of premium overcharges for the top six states for sorghum:

	N	Low	High	Q1	Q2	Q3	Mean	Mode	STD
Texas	27	0.00	0.18	0.00	0.01	0.05	0.04	0.00	0.06
Arkansas	4	0.03	0.13	0.04	0.08	0.12	0.08	0.03	0.05
Colorado	3	0.01	0.14	0.01	0.02	0.08	0.06	0.01	0.07
Kansas	3	0.05	0.15	0.07	0.08	0.11	0.09	0.05	0.05
New Mexico	3	0.07	0.51	0.08	0.08	0.30	0.22	0.07	0.25
Oklahoma	3	0.03	0.43	0.22	0.40	0.42	0.29	0.03	0.22

Table 5.8: Premium overcharges for top six states for sorghum.

Figure 5.6 shows the geographic distribution of sorghum premium overcharges in the contiguous united states:

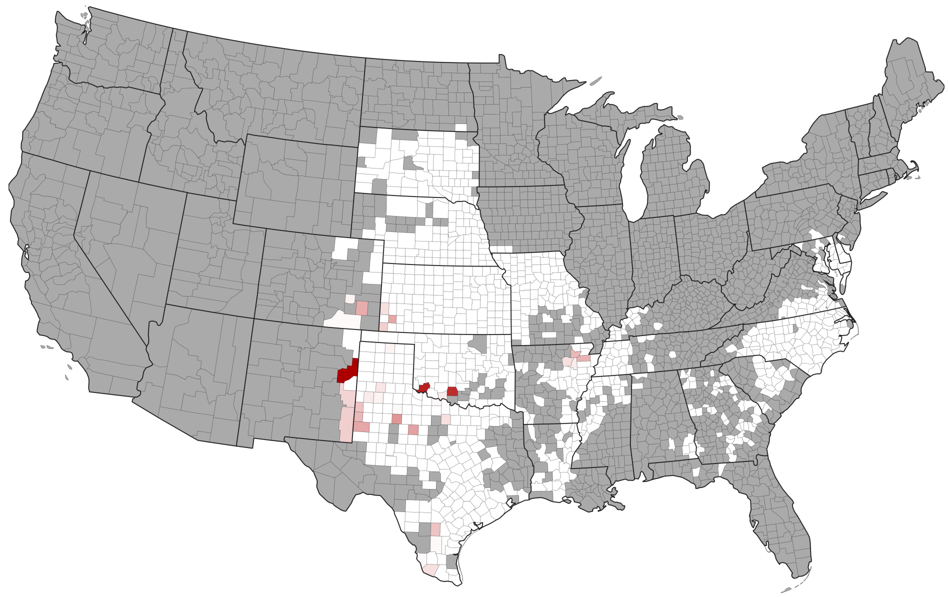

Figure 5.5: Geographical distribution of sorghum premium overcharges.

The geographic distributions of both soybean and sorghum overcharges vary, however they share certain similarities. For the top six states for both crops the mean values of premium overcharges are all below one normalized premium. The standard deviations of the soybean states, however, are generally higher than those of the sorghum states. A large share of observations for sorghum and for soybeans come from single states, Texas and Georgia respectively.

Table 5.9 shows the summary statistics for the top six states for the cotton case:

	N	Low	High	Q1	Q2	Q3	Mean	Mode	STD
Texas	80	0.01	25.37	0.30	0.79	10.98	5.41	0.04	7.32
Oklahoma	19	0.31	28.30	3.38	7.86	12.91	10.43	0.31	9.05
Kansas	8	3.73	24.29	13.81	21.44	21.86	17.28	3.73	7.77
North Carolina	6	0.13	2.92	0.26	0.87	2.04	1.21	0.13	1.18
South Carolina	6	0.04	15.87	1.60	1.80	3.51	4.19	0.04	5.86
Louisiana	2	7.08	16.87	9.53	11.98	14.42	11.98	7.08	6.92

Table 5.9: Premium overcharges for top six states for cotton.

Figure 5.7 shows geographically the distribution of cotton premium overcharges throughout the contiguous United States:

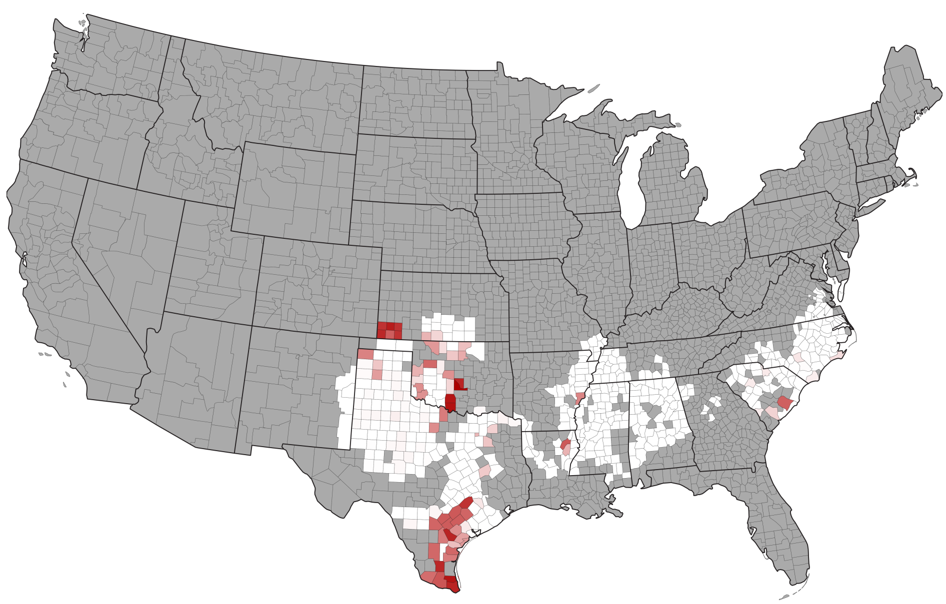

Figure 5.6: Geographical distribution of cotton premium overcharges.

Cotton differs from the above four crops in terms of where in the country premium overcharges are located, as well as the magnitude of premium overcharges. From Table 5.9 the mean values of premium overcharge in each of the top six states is larger than for the other four crops. As well, the variation within each state is generally higher. Geographically, a larger share of cotton premium overcharges occur in Texas and Oklahoma than in any other state.

5.3 Implications

Premium overcharges affect several aspects of the Federal Crop Insurance Program, including program costs, costs to producers, and producer participation rates. Sections 5.1 and 5.2 show that for a certain subset of SCCTP combinations in the 2022 crop year, the application of Yield Exclusion causes changes in premiums that are actuarially unfair. These premium overcharges were found, and calculated for 24 states, and found for 5 different field crops. In these cases, the premium charged for an increase in the approved yield, and subsequent increase in coverage level, exceed the maximum amount of additional expected indemnity that a producer would receive. This points to misratings of premiums for these particular SCCTP combinations. This has the effect of increasing producer's costs of risk management, and lowering the incentives for participation in the Federal Crop Insurance Program. For illustrative purposes the effects of this premium overcharge are shown through the example of a representative Texas cotton producer. Utilizing the average cotton premium overcharge in Texas, with a projected price of $1.02 per pound, an approved yield of 630 pounds per acre post Yield Exclusion election, could expect to pay premiums that are $3476.46 in excess of the indemnities they could expect to receive. Conversely, receiving premiums in excess of expected indemnities improves the financial position of AIPs, and reduces program costs. For these specific SCCPT combinations, the rating methodology needs to be adjusted, and premiums brought down to maintain actuarial fairness in the crop insurance program.

Examining the geographic distributions of the lower bounds of premium overcharges, it can be seen that certain regions experience more overcharges than others. Growing regions in the Western, and Southern states feature more prominently than those in the Atlantic seaboard, New England and the Midwest. Regions with greater variability in inter year crop yields have more variability in their crop yields inter year, and are more likely to experience dry land cropping conditions. This is seen through the number of observations coming from states such as Texas, Oklahoma, and Kansas. As well, crops typically grown in dry land conditions have larger mean values of premium overcharge, as well as greater variability in their values of premium overcharge. These crops include cotton, sorghum, and wheat. This points to issues in how the premium increases caused by the election of YE are calculated for regions with greater yield variability and drier growing conditions.

This analysis looks only at the lower bounds of premium overcharge caused by the election of YE from SCCTP combinations with premium implied yield distributions that are poorly specified. As this is the case these results are expositionary, in that a more thorough examination of the effects of Yield Exclusion on the actuarial fairness of the FCIP may be warranted. The results here, however, do indicate that for certain cases, the premiums charged for the additional coverage offered by YE exclusion, are far in excess of what a producer could expect in expected indemnities from that increase in coverage. For these cases, the rating methodology for increases in premiums caused by the election of YE need to be amended. Particularly, the increase in premium caused by the election needs to be decreased. Doing so will aid in maintaining the availability and viability of crop insurance to all producers, as well as better align the Yield Exclusion policy option with the FCIP goals of actuarial fairness.

6. SUMMARY AND CONCLUSIONS

This paper utilizes an empirical methodology to explore the actuarial fairness of the Yield Exclusion policy option in the Federal Crop Insurance Program. The primary means through which this was accomplished, was through the examination of the lower bounds of premium overcharge caused by the election of Yield Exclusion. These premium overcharges were evaluated on a crop by crop and geographical basis for corn, cotton, wheat, grain sorghum, and soybeans. In all 438 premium overcharges were calculated for these five field crops. It was found that premium overcharges are clustered around certain geographic regions in the southern and western states. As this is the case, premium increases caused by the election of Yield Exclusion can be seen to be more onerous to producers in these regions than others in the contiguous United States. These results point to the need for better calibration of the premiums charged for the election of the Yield Exclusion policy option and better calibration of YE premiums to differing risk profiles across the crops examined.

Moving past this paper, an investigation of the net effects of the Yield Exclusion policy option on the actuarial fairness of the FCIP is needed. This could lead to better premium rate setting procedures, and rates that are more representative of the underlying effects of the Yield Exclusion policy option. As well, a further examination of how, and the effects, of differences in rate setting across geographic regions is needed. This could help to remedy differences in producer participation and financial outcomes in particular regions. The results of this paper are dependant on the number of years that are eligible for exclusion from the calculation. Further empirical study on the effect of changing the number of excluded years on actuarial fairness is needed. Although this paper lends credence to the notion that the premiums charged for the election of YE are in excess of the additional indemnification from higher coverage levels, a further investigation on the effect of YE on the budget of the FCIP, as well on its effect on producer participation are necessary next steps.

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