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Francis Tsiboe

Agricultural Risk Policy Center, North Dakota State University

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Francis Tsiboe, Senior Research Economist and Program Leader, Agricultural Risk Policy Center (ARPC), North Dakota State University, Richard H Barry Hall, 811 2nd Ave N, Fargo ND 58108-6050. Email: francis.tsiboe@ndsu.edu / ftsiboe@hotmail.com

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Abstract

The substantial fiscal commitment of government-subsidized agricultural insurance highlights its critical role in supporting farmers, yet it also reveals the program's financial vulnerability amid debates over fiscal cuts aimed at easing pressure on the public purse. Central to these debates is the need for actuarially sound premium rates. This study, which analyzes more than three million observations across 33 commodities from 2001 to 2024 in the United States context, examines how innovations in ratemaking affect taxpayer obligations. The findings indicate that updating the parameters used to calculate crop insurance costs for farmers can significantly reduce taxpayer expenses. Updating all the ratemaking parameters together saves about 10% annually, however, targeting just one component, such as the reference yields, can yield annual savings of up to 13%. Although most states benefit from these updates, precise ratemaking falls short in a few cases. Overall, the results highlight the complexities of setting premium rates that are both actuarially and fiscally sound, suggesting that smarter, targeted updates could improve the efficiency of the program and alleviate the financial burden on taxpayers.

Keywords: crop insurance; premium rate; subsidies; actuarial science; fiscal responsibility; cost cuts, taxpayer savings

JEL codes: Q14, Q17, Q18, G22, H72

1. Introduction

Agricultural producers have long sought ways to manage risk and reduce volatility inherent in their operations. Many supplement private risk management strategies with government-subsidized programs such as agricultural insurance (Baldwin, Williams, Tsiboe, et al. 2023; Mahul and Stutley 2010; Smith and Glauber 2012; Belasco 2020; Turner and Tsiboe 2022; Tsiboe and Turner 2023; Baldwin, Williams, Sichko, et al. 2023; Turner et al. 2023).[1] While these programs are often credited with enhancing income stability, promoting rural development (Azzam et al. 2021; Lee 2021; Ifft et al. 2024; DeLay et al. 2023), and supporting food security (Savary et al. 2012; Lusk 2017), their broader macroeconomic contribution remains subject to debate. The fiscal commitment required to maintain such programs has prompted questions about their long-term efficiency and whether the social benefits truly outweigh the costs (Joseph Glauber et al. 2021; Mahul and Stutley 2010; U.S. Government Accountability Office [U.S. GAO] 2023; United States Government Accountability Office [GAO] 2014). Indeed, comprehensive cost–benefit analyses of agricultural insurance remain limited, partly due to the methodological challenges of quantifying welfare gains and risk reduction benefits in monetary terms. These unresolved issues underscore the importance of examining not only the effectiveness of actuarial mechanisms in sustaining the program's fiscal integrity but also their implications for the broader debate over the efficiency of subsidized agricultural insurance.

One of the longest-standing and largest government subsidized agricultural insurance is the U.S. Federal Crop Insurance Program (FCIP) (Baldwin, Williams, Tsiboe, et al. 2023; Baldwin, Williams, Sichko, et al. 2023; Turner and Tsiboe 2022; Turner et al. 2023; Baldwin et al. 2024;

[1] As of 2007, about half of all countries had some sort of agricultural insurance (Mahul and Stutley 2010).

Knight and Coble 1997). Since its inception in the 1930s, the FCIP has grown to insure approximately 543 million acres and $192 billion in production value across over 140 commodities as of the 2024 crop year.[2] Through this program, the U.S Federal Government subsidized 61% [$7.25 billion annually] of the insurance premiums for producers annually from 2001 to 2024 and allocated $1.80 billion each year to Approved Insurance Providers (AIPs) through a public-private partnership, ensuring the program's delivery to agricultural producers. The net total cost (i.e., taxpayer obligations) of FCIP averaged $8.97 billion annually during this period, with an annual real growth rate of 8.43%.

Central to the fiscal integrity of government subsidized agricultural insurance is the necessity of establishing premiums that are actuarially sound. Actuarially sound premiums must align closely with the true risk of crop loss, reflected in a loss ratio (LR), the quotient of indemnities to premiums, of exactly 1.0, ensuring that premiums are neither overpriced nor insufficient. In the U.S. context, the Federal Crop Insurance Act, particularly under Section 508(d), mandates that the Risk Management Agency (RMA), which oversees the FCIP, not only sets premiums to cover expected indemnities but also incorporates a reasonable disaster reserve into the rating systems to manage unforeseen large-scale losses. This dual requirement underscores the RMA's role in balancing financial sustainability with risk management, ensuring the program's ability to respond to both typical and catastrophic agricultural risks.

This study aims to evaluate how actuarial innovations, specifically routine, data-driven recalibrations to rating parameters, contribute to the program's fiscal integrity. Focusing on the FCIP, the research employs a counterfactual simulation approach to estimate what loss outcomes

[2] All dollars are in 2024 real terms.

would have been if the rating parameters had not been updated in a given crop year. In this method, the impacts of these innovations are determined by comparing the hypothetical outcomes under a "no update" scenario with the actual outcomes observed after the updates. A key element of the simulation is a "roll-back" approach, where the current year's actuarial data is replaced with that of the previous year and premiums are recalculated based on the actual loss outcomes. This technique, combined with adjustments in crop insurance demand that respond to changes in premium rates, captures not only the static fiscal impacts but also the dynamic behavior of market participants. The simulation was retrospectively applied to the RMA's summary of business and actuarial data master from 2001 to 2024.

The results show that updating rating parameters reduced the financial burden of FCIP on taxpayers by about 10% each year from 2002 to 2024 from a baseline of $7.33 billion. This means that by pricing insurance products in an actuarial sound manner, the program is nudged closer to fiscal soundness. When targeted changes to specific components of the actuarial data master are considered, even larger savings are possible. For example, updating only the reference rate, fixed rate, rating exponent, or reference yield results in cost reductions of 12%, 11%, 10%, and 13%, respectively. Although most years showed consistent cost reductions, there were exceptions in 2002 and 2005, when these actuarial updates did not fully relieve the fiscal burden. At the state level, the savings varied according to each state's agricultural setting, risk, and the size of its crop insurance footprint. States with larger areas enrolled in the program, like Illinois, Indiana, Wisconsin, Ohio, Michigan, Iowa, Missouri, Nebraska, South Dakota, North Dakota, and Minnesota, generally have more data to set rates accurately, leading to better savings. In contrast, states with smaller or more volatile agricultural settings, such as Alaska, Rhode Island, and New Mexico, did not experience significant cost reductions from these updates, while a few states, including Arkansas, North Carolina, Oklahoma, Louisiana, Texas, Utah, California, and Florida, even showed modest positive net costs.

This study makes three key contributions worth highlighting. First, the study advances FCIP ratemaking literature by offering new insights into actuarial updates (mainly driven by the inflow of new information) an often-overlooked area. Extensive research has explored various strategies to enhance the actuarial performance of the FCIP including reform to its ratemaking methodology (Park et al. 2019; Goodwin and Hungerford 2015; Woodard et al. 2011; Ramirez et al. 2011; Skees and Reed 1986; Goodwin 1994; Carriquiry et al. 2008; Nelson 1990; Turner et al. 2025), technology-induced yield trends (Adhikari et al. 2012; Seo et al. 2017), heteroscedastic yields (Harri et al. 2011; Annan et al. 2014), and the accommodation of extra sources of information (soil and weather) to improve rates (Tsiboe and Tack 2022; Woodard and Verteramo-Chiu 2017; Liu and Ramsey 2023; Rejesus et al. 2015). Yet, how these modifications translate to improve the fiscal integrity of the FCIP remains largely unaddressed. This study enhances the understanding of this linkage by using a simple but robust method that utilizes the timing of lagged rating adjustments, informed by historical loss experiences. This approach effectively highlights the directional impact of these adjustments on the fiscal landscape of the FCIP. The methodology not only broadens the comprehension of these matters but also emphasizes the critical importance of rating adjustments vis-à-vis the proposed overhaul of the current FCIP ratemaking methods.

Secondly, government publications on the costs of the FCIP range from very simple to highly complex, often leading to misunderstandings about key cost components. For instance, payments made to AIPs (the companies responsible for delivering the program) are frequently misinterpreted, as are items related to how underwriting gains and losses are shared between the government and the companies. In many cases, the government's share of underwriting gains and losses is scarcely presented, compounding confusion. Such ambiguities can lead to misconceptions regarding the overall costs and benefits of the program for producers, taxpayers, and the companies involved. This paper helps alleviate some of this confusion by providing consolidated, intuitive descriptions of the key fiscal elements of the FCIP, thereby offering a more complete and transparent understanding of its fiscal landscape.

Finally, this study leverages granular data, breaking down observations into insurance pools within each county to minimize aggregation bias and ensure similar units are analyzed together. It expands on previous research by including a diverse set of 33 commodities and seven insurance plans, covering approximately 81% of the FCIP liability and 70% of the acreage insured from 2001-2024. This detailed approach enhances the understanding of actuarial adjustments and the complex interdependence influencing policy in the FCIP.

2. Fiscal Landscape and Actuarial Updates in US Agricultural Insurance

2.1 FCIP overview and background

The FCIP provides risk management for most U.S. crops, protecting against financial losses from adverse conditions. Created in 1938 in response to the Great Depression and a struggling private insurance market, it initially covered only wheat. After soaring disaster payments and low participation in the 1970s, Congress passed the Federal Crop Insurance Act of 1980 to expand coverage, introduce premium subsidies, and involve private insurers. Subsequent legislation further broadened options, boosted subsidies, and integrated the FCIP with other USDA programs, firmly establishing it as a cornerstone in the U.S. agricultural farm safety net.

The government entities in the FCIP public-private partnership are USDA's Federal Crop Insurance Corporation (FCIC) and the Risk Management Agency (RMA); private entities are

Approved Insurance Providers (AIPs) (see Figure 1).[3] The FCIP is governed by the FCIC Board and managed by RMA, offering innovative crop insurance for multiple perils. AIPs sell and service FCIC-approved policies nationwide, while RMA approves products, sets premium rates, subsidizes farmers' premiums, covers AIPs' Administrative & Operating (A&O) costs, and reinsures catastrophic losses. Additionally, FCIC reinsures publicly delivered crop insurance in Puerto Rico through the Corporación de Seguros Agrícolas, ensuring comprehensive coverage for America's producers.

The RMA administers the program through the standard reinsurance agreement (SRA) and the livestock price reinsurance agreement, setting terms for policy servicing, A&O subsidies, and underwriting gains/losses. The current SRA was last renegotiated in 2010, and the current livestock agreement was last renegotiated in 2002.

2.2 FCIP fiscal landscape

Unlike many farm programs, the FCIP is permanently authorized under the Federal Crop Insurance Act (7 U.S.C. §1501 et seq.), which provides "such funds as are necessary" for administrative and operating costs, premium subsidies, and related uses. In contrast, RMA resources and employee renumerations relies on discretionary funding through annual appropriations, which averaged about $75 million per year from 2001 to 2024 with a 1.35% annual growth rate during the same period (see Table S1 in the online appendix). External program funding may come from three main sources: (1) producer-paid premiums, (2) producer-paid Catastrophic coverage (CAT) fees, and (3) underwriting losses assigned to AIPs. For cost, this study categorizes program costs into: (1)

[3] Of the 13 RMA-designated insurers in 2022, six with U.S.-domiciled parent companies accounted for 28% ($1.0 billion), and seven with foreign-domiciled parents in Australia, Bermuda, Canada, Japan, and Switzerland, accounted for 72% ($2.7 billion) of total A&O subsidies and underwriting gains.

premium subsidies provided directly to producers, (2) total indemnities fronted by FCIC, (3) program delivery costs, and (4) underwriting gains allocated to AIPs.

Subsidies

The federal crop insurance program features three primary subsidies: producer premium subsidies, A&O and Catastrophic Loss Adjustment Expense (CAT LAE) payments to AIPs, and shared underwriting risk with AIPs. Table 1 provides an overview of total premiums (column 2) and producer premium subsidies (column 3) from 2001 to 2024. Over the years, Congress has repeatedly raised premium subsidy rates - in 1980, 1994, 1998, 1999, and 2000 - and most recently for the 2026 crop year through the One Big Beautiful Bill (Public Law 119-21), signed on July 4, 2024. Generally, subsidy rates decrease as coverage levels increase, except for supplemental policies with static premium subsidy rates. As shown in Table S2, yield and revenue policies with higher coverage levels have subsidy rates between 37 and 80 percent, while CAT remains fully subsidized (100 percent). From 2001 through 2024, premium subsidies totaled $174 billion in 2024-adjusted dollars – an average of roughly $7.25 billion per year – and in 2024 alone, these subsidies totaled around $10.43 billion. These premium subsidies, which have historically been the primary policy tool to increase program participation (Tsiboe and Turner 2023; Coble and Barnett 2013; Just et al. 1999; Glauber 2013; Glauber 2004), represent the largest share of total program cost.

Program delivery generally involves marketing, application processing, premium collection, and claim adjustment. The FCIC offsets these costs for AIPs by paying two subsidies: A&O for buy-up coverage, and CAT LAE for CAT coverage. Both are paid separately by the government, calculated as a percentage of premium rather than actual costs. Under the SRA, A&O from 2000-2024 ranged from 12% to 27% depending on the insurance plan and coverage level of the policy being delivered (see Table S3), with a “snapback” bonus – set at 1.15% of premium in states whose loss ratio exceeds 1.2, while CAT LAE is set at 6%.[4] In 2011, the SRA imposed annual A&O limits (a $1.3 billion cap and a $1.0 billion cup), which remain unchanged through 2024. Certain CAT LAE and A&O subsidies are excluded from these limits.

Compensation to crop insurance agents is the largest single delivery expense for AIPs. Because RMA sets premium rates, AIPs cannot compete on price, so they focus on agent relationships and customer service, hiring successful agents to drive business (U.S. Government Accountability Office [U.S. GAO] 2023; Congressional Research Service [CRS] 2018). This has led to a highly competitive agent market (DeLay and Walters 2024). The 2011 SRA and subsequent agreements limit what AIPs can pay agents by capping the portion of A&O and CAT LAE used for base commissions at 80% per state. However, AIPs may offer up to 100% under certain conditions. There is no specific restriction on any individual agent’s compensation if the total statewide limit is not exceeded. Thus, an AIP could pay one agent the entire 80% allowance in a state, provided no commissions go to any other agent in that state. Table 1 shows that from 2001 through 2024, the federal government paid private insurance companies about $43.24 billion in 2024-adjusted dollars, an average of roughly $1.80 billion per year, to deliver the program. For 2024, these subsidies are projected to total around $2.44 billion.

Indemnities

Indemnity payments are the funds FCIP pay to producers with a crop insurance policy to compensate them for covered losses. All indemnity payments are initially counted as an FCIC cost.

[4] The One Big Beautiful Bill added yet another “snapback” A&O subsidy for the high loss states at a rate of 6% of premium.

However, under the SRA, these payments are shared between FCIC and AIPs when calculating underwriting gains or losses. From 2001 to 2024, the FCIP paid a total of $236.13 billion in indemnities, adjusted to 2024 dollars, averaging $9.84 billion per year. For 2024, indemnity payments reached $12.76 billion. Although annual payouts vary, they have generally trended upward, with real indemnities rising about 12 percent each year. Notably, real indemnities spiked in 2011, 2012, 2019, and 2022 by 122 percent, 53 percent, 47 percent, and 74 percent, respectively, often in response to extreme weather events such as severe droughts. The 2022 Census of Agriculture also indicates significant regional disparities in these payments, reflecting diverse risks and losses nationwide (Tsiboe 2024).

Underwriting

Under reinsurance agreements, the government and private insurers share underwriting gains and losses (See Tables S4 in the online appendix). Insurers retain a portion of total premiums (retained premiums) and cede higher-risk policies to the government, typically through the Assigned Risk Fund. This fund often covers areas prone to greater losses, such as those with frequent drought or flooding, while insurers keep lower-risk policies in the Commercial Fund. Each year, companies' gains or losses are determined by the difference between retained premiums and the share of claims they pay, adjusted by gain/loss and quota sharing provisions. Net underwriting gains are when premiums exceed total payments to producers for claims while net underwriting losses are when premiums are less than payments for claims.

From 2001 to 2024, AIPs retained about 80% of total premiums, and Table 1 shows that this resulted in the FCIC paying total net underwriting gains of $45.84 billion in 2024-adjusted dollars to AIPs, an average of roughly $1.91 billion per year. Among the three major cost items examined in this study, underwriting gains paid by FCIC to AIPs ranked second in overall direct FCIP expense, comprising about 23% of total costs annually from 2001-2024. In 2024, the FCIC paid AIPs $4.05 billion in underwriting gains. From 2001 to 2024, the AIPs paid a total net underwriting loss of $1.52 billion to the FCIC, an average of roughly $0.06 billion per year. These shared underwriting costs (or gains) change with annual losses. Typically, the FCIC pays significant underwriting gains to AIPs, but in 2002 and 2012, AIPs transferred funds back to the FCIC.

Net direct cost – Taxpayer obligation

The AIPs collect producer premiums and transfer them to FCIC within weeks. FCIC does not directly pay premium subsidies; instead, these are factored into underwriting gains and losses. Each AIP has an FCIC-funded escrow account through which FCIC initially pays all indemnities. On a monthly basis, the RMA then calculates each AIP's share of these indemnities based on retained risk and FCIC-paid premium. Depending on the calculation, AIPs may owe FCIC a portion of the indemnities already advanced. At the end of each reinsurance year, a final settlement process accounts for all risk-sharing terms (such as fund allocation, proportional reinsurance, and nonproportional reinsurance) across crops and states, determining the final division of gains or losses.

From 2001 to 2024, non-taxpayer inflows, primarily from collected premiums and underwriting losses paid by AIPs to FCIC, totaled $283.84 billion (in 2024-adjusted dollars), averaging $11.83 billion per year. Except for 2002 and 2012, these inflows came solely from premiums. Meanwhile, premium subsidies, indemnities, A&O expenses, and underwriting gains paid by FCIC to AIPs reached $499.14 billion, or $20.80 billion annually. Subtracting inflows from outflows, the FCIP net direct cost was -$215.30 billion over the period, an average of -$8.97 billion per year. This net cost is covered by permanent funding authorized under the Federal Crop

Insurance Act (7 U.S.C. §1501 et seq.), providing "such funds as are necessary" for the program's operations, premium subsidies, and related expenses.

According to the Congressional Budget Office's May 2023 estimates, the crop insurance program will cost over $101 billion (around $10.1 billion per year) from 2024 to 2033. This underscores the continued challenge of balancing financial sustainability with risk management, ensuring protection for producers against both routine and catastrophic agricultural risks.

2.3 FCIP actuarial updates

Producers that purchase a crop insurance policy within the FCIP must choose from several options that ultimately define the policy and the price they pay for it. These include which insurance plan to enroll in, a coverage level for the plan, and which unit structure to insure under. The combination of these choices in addition to where they are located (county), what they produce (commodity), and how they produce (production practice) alters the properties of the final insurance policy allowing a producer to customize their policy to fit their unique risk management needs.

Given the complexity of the producer's choice, premium rates are established through a sophisticated method known as loss-cost ratio ratemaking (Coble et al. 2010; Coble et al. 2020). Under this framework, rates are first determined at the sub-county (insurance pool) level for a standard coverage option, and then adjusted using techniques that mirror the experience-based and risk-differentiation approaches found in property and casualty insurance (Sherrick et al. 2014). The objective here is to simplify these procedures, with particular attention to policies derived from producers' actual farm-level data: namely Actual Production History (APH), Yield Protection (YP), Revenue Protection (RP), and Revenue Protection with Harvest Price Exclusion (RP-HPE)

Yield-based policies (YP and APH) include eight key elements: the rate yield ($\bar{y}$), approved yield ($\ddot{y}$), coverage level (θ), indemnity ($I(y)$), premium rate (τ), premium (P), and subsidy (S). Both the rate yield and the approved yield are computed using a producer's average historical production, as reported in the APH. However, the approved yield often undergoes upward adjustments through various components of RMA's actuarial processes (e.g., yield exclusion, yield substitution, and trend adjustments). Once a coverage level θ is selected, the producer secures a yield guarantee (liability) equal to $\theta\ddot{y}$. The per-acre indemnity, given an observed yield y, is determined by $I(y) = \max[0, \theta\ddot{y} - y]$.

Because premium rates are intended to be actuarially sound, the total premiums collected over time should match total indemnities paid. To achieve this, the premium rate per dollar of liability is defined as:

$$\tau(\theta) = \frac{E[I(y)]}{\theta\ddot{y}} = \frac{1}{\theta\ddot{y}} \int_0^{\theta\ddot{y}} (\theta\ddot{y} - y) f(y) dy \quad (1)$$

where $f(y)$ is the probability density function describing the underlying yield distribution. In practice, RMA assumes that $f(y)$ depends on a risk-adjustment mechanism which estimates a producer's risk level relative to their peers. This adjustment is captured via the RMA's "continuous rating formula" (Milliman & Robertson 2000; Risk Management Agency [RMA] 2000; Risk Management Agency [RMA] 2009). For yield-based coverage (YP and APH), the continuous rating formula is approximated by

$$\tau_{ijt} = \left[\alpha_{jt}\left(\bar{y}_{ijt}/\bar{y}_{cjt}\right)^{\beta_{jt}} + \delta_{jt}\right] F^{\theta}_{ijt} F^{u}_{ijt} \quad (2)$$

where ijt identifies a specific insured producer i, in a given insurance pool j for crop year t. The parameters α_{jt} and δ_{jt} serve as, respectively, the reference rate and a fixed loading factor for catastrophic events at a standard coverage level (often 65%). The term $\bar{y}_{ijt}$ (rate yield) is the producer's average historical yield, and $\bar{y}_{cjt}$ is the mean yield for all producers in the same county, making $\bar{y}_{ijt}/\bar{y}_{cjt}$ a measure of the producer's performance relative to their insurance pool. A negative exponent β_{jt} scales rates downward for more productive operations, and this component is known as the rate multiplier curve ($(\bar{y}_{ijt}/\bar{y}_{cjt})^{\beta_{jt}}$). Finally, F^{θ}_{ijt} and F^{u}_{ijt} adjust the rate based on the chosen coverage level (θ_{ijt}) and insurance unit (u_{ijt}).[5]

For those opting for revenue-based protection (RP or RP-HPE), the premium rate is calculated using a simulation that blends yield and price distributions—along with their correlation—to produce a "revenue load." This load, equal to the difference between a simulated revenue-based rate and a yield-based rate, is added to the base yield insurance rate to reflect the extra risk of covering revenue variability. Consequently, the final premium rate for revenue coverage is adjusted to account for this additional risk.

The overall cost of the contract is then $P = \tau(.)\theta\ddot{y}$. Producers benefit from a subsidy, $S(\theta, u)$, which depends on the chosen coverage level and insurance unit type, rather than on their location or specific crop.

The RMA sets and periodically revises the continuous rating parameters (α, δ, β, and $\bar{y}_c$), incorporating advances in technology, methodology, and factors like climate change. Using empirical methods from the early 1980s (Sherrick et al. 2014) augmented with weather weighting

[5] Producers may choose different unit structures to customize the scope of their insurance coverage. In the most detailed option, Optional Units (OUs) treat each field as a separate policy, enabling highly specific coverage. At the other end of the spectrum, Enterprise Units (EUs) group all fields of a given crop within a county into a single contract, maximizing consolidation. Basic Units (BUs) offer a middle ground by pooling land based on crop, county, and ownership/share arrangements.

(Rejesus et al. 2015) to adjust insurance experience, the reference rate (α) for an insurance pool is calculated as the annual average of the pool's historical loss cost ratio (LCR), which is capped to mitigate the impact of outlier catastrophic events (Coble et al. 2010). The excess risk from the capped LCR determines the catastrophic fixed loading factor (δ), which also includes prevented planting, replant, and quality adjustment loads. The RMA reviews these rates every three years, analyzing data from a rolling 20-year period starting two years prior to the relevant crop year (see Figure S1 for the case of updating rates for 2018 and 2019 crop years).

Program yields are regularly updated to reflect changes in weather, climate conditions, genetics, technology, and farming practices. Specifically, reference yields are determined from the acre-weighted average of yields reported by crop insurance participants for the most recent crop year. In situations with limited data, the RMA utilizes different levels of aggregation or statistical models. These yield reviews are synchronized with rate reviews occurring every three years and incorporate the latest 10 years of yield data (Rejesus et al. 2010).

The RMA employs hierarchical structuring of data to estimate exponents, organizing individual data within counties, then grouping these within climate regions, and finally nesting within states. This approach supports the use of sophisticated multilevel modeling techniques, which strike a balance between no pooling (estimating the exponent separately for each geographic area) and total pooling (using a single exponent for all areas). Multilevel models allow for nuanced assessments that reflect regional yield variations and loss ratios. RMA calculates these exponents by correlating producer-reported average yields with actual realized yields over historical data, thus estimating the exponential relationship between unit-level yield ratios and loss cost ratios (Tsiboe and Tack 2022). Aside the parameters relevant to this study, RMA also implements regular reviews of other aspects of the program such as dates, maps, availability, and reporting to ensure that the program remains adaptive and accurate (Baldwin, Williams, Tsiboe, et al. 2023; Baldwin, Williams, Sichko, et al. 2023).

In what follows, this study simulates the impacts of RMA's actuarial updates on the fiscal landscape previously discussed in this section.

3. Data and Variable Construction

The core dataset for this study comes from the RMA's most detailed Summary of Business, which spans the 2001–2024 crop years. Referred to as "SOBTPU" (Summary of Business by Type, Practice, Unit Structure), each record in this dataset merges the collective outcomes of producers who share the same insurance pool, contract attributes, and same crop year.[6] Insurance pools reflect the smallest geographic units used by the FCIP to set rates, and are defined by unique combinations of county, crop, crop type (for instance, grain versus silage for corn), and production practice (e.g., irrigated, organic). The contract choices are defined by unique combinations of insurance plan (e.g., APH, RP, etc..), coverage level, and unit structure (OU, EU, etc..).

The study concentrates on insurance plans that use the continuous rating framework. Over the analysis period, multiple continuous-rating plans were restructured through the introduction of "COMBO" policies in 2011, which consolidated existing products. Specifically, APH plans for crops trading on well-established futures markets became YP; Crop Revenue Coverage (CRC) and Revenue Assurance (RA) plans with a harvest price option (HPO) were merged into RP; and RA without HPO and Income Protection (IP) were combined into RP-HPE. As a result, any SOBTPU

[6] SOBTPU files for each crop year are available at (Risk Management Agency [RMA] 2023b).

or ADM entry previously labeled APH was recoded as YP, any CRC entry was recoded as RP, and any RA or IP entry was reclassified as RP-HPE.

Each record from SOBTPU includes core loss experience variables: coverage level (θ_{ijt}), net insured acres (A_{ijt}), liability (L_{ijt}), total premium (P_{ijt}), subsidy amount (S_{ijt}), and indemnity amount (I_{ijt}). From these, the premium rate per dollar of liability (τ_{ijt}) is derived by dividing the total premium by total liability, while the subsidy per dollar of premium (s_{ijt}) is computed by dividing the subsidy amount by the total premium.

In addition to the SOBTPU, the study also uses RMA's Actuarial Data Master (ADM) for 2001–2024.[7] From the ADM, parameters are extracted necessary for continuous rating, including the county reference rate (α_{jt}), county fixed rate (δ_{jt}), county rating exponent (β_{jt}), county reference yield ($\bar{y}_{cjt}$), and differential factors separately for coverage level (F_{ijt}^{θ}) and unit structure (F_{ijt}^{u}). For a given SOBTPU entry, these parameters were taken as their exact values retrieved from the ADM. For missing coverage-level adjustment factors, a regression-based strategy is applied, modeling each factor as a quadratic function of the coverage level and the 65% reference rate, estimated separately for each crop and year (Coble et al. 2010).

Given the SOBTPU and ADM data, the rate yield ($\bar{y}_{ijt}$), intended to approximate the average productivity for the group of producers aggregated in each SOBTPU record, is back-calculated according to

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[7] ADM files for each insurance year are available at (Risk Management Agency [RMA] 2023a). The aggregation of ADM information is based on initial work by (Tsiboe and Tack 2022) using Beocat, a High-Performance Computing (HPC) cluster at Kansas State University.

$$\bar{y}_{ijt} = \bar{y}_{cjt}\left[\left(\frac{\tau_{ijt}}{F_{ijt}^{\theta}F_{ijt}^{u}} - \delta_{jt}\right)\frac{1}{\alpha_{jt}}\right]^{\frac{1}{\beta_{jt}}} \quad (3)$$

Table 2 summarizes the descriptive statistics for the dataset, which comprises 3,783,753 SOBTPU entries covering 33 crops between 2001 to 2024.[8] Overall, the sample represents 81.48% of the non-livestock liability in the FCIP during this period. On average, each entry corresponds to an insured area of 1,280 acres, a coverage level of 73%, and a total liability of \$481,720. The associated total premium is \$49,081, with approximately \$30,353 subsidized by the government, yielding mean values of \$0.14 for premium per dollar of liability and \$0.61 for subsidy per dollar of premium. The dataset is dominated by seven crops, corn, soybeans, wheat, cotton, sorghum, barley, and rice, which together account for 94.2% of the insured acreage. At the pool level, these crops have average insured acres (and corresponding liabilities) of 1,532 acres (\$785,665), 1,453 acres (\$496,601), 1,398 acres (\$241,612), 1,130 acres (\$419,912), 714 acres (\$120,117), 671 acres (\$104,337), and 935 acres (\$642,440), respectively. Their respective average premium per dollar of liability (subsidy per dollar of premium) are \$0.11 (\$0.61), \$0.11 (\$0.61), \$0.16 (\$0.61), \$0.19 (\$0.64), \$0.23 (\$0.62), \$0.16 (\$0.6), and \$0.08 (\$0.6). See Table S5 in the online appendix for other major crops not listed on Table 2.

Next, we examine how actuarial parameters change over time, the "update rate" for each crop year, defined as the percentage of insured acreage that experienced any change in its actuarial parameters. For each insurance pool, an update event is flagged whenever the parameter value in the ADM for the upcoming crop year differs from that of the preceding year. As shown in Figure 2, annual variations in update rates within the FCIP (2001 to 2024) reflect the RMA's structured

[8] The crops included alfalfa seed, almonds, barley, blueberries, canola, corn, cotton, cucumbers, dry beans, dry peas, flax, forage, millet, mustard, oats, onions, peaches, peanuts, potatoes, rice, rye, safflower, sesame, sorghum, soybeans, sugar beets, sugarcane, sunflowers, sweet corn, tobacco, tomatoes, walnuts, and wheat

review cycle. Specifically, certain years, such as 2004 (95.84%), 2005 (100%), 2009 (96.4%), 2014 (95.13%), 2018 (97.98%), 2021 (96.65%), and 2024 (98.61%), feature near-complete or total updates, consistent with the comprehensive reviews that draw on extensive historical data and account for new risks and changing market conditions. Conversely, years with lower update percentages, such as 2011 (47.87%), 2008 (46.85%), and 2002 (27.06%), typically fall mid-cycle when fewer adjustments are necessary.

A comparable pattern emerges when looking at individual parameter updates, although before 2012 the rating exponent saw minimal revisions. In addition, the county reference yield exhibits a notable break in continuity due to a shift in the RMA's approach. Previously, reference yields were updated using transitional yields (T-yields), but beginning in 2011, the RMA transitioned to calculating yield updates based primarily on an acre-weighted average of yields reported by crop insurance participants for the most recent available year. [9]

Figure 3 illustrates that field crops exhibit the highest mean annual rate of actuarial parameter updates, at approximately 78.96% of their insured acreage. Field Crops succeeded by updates for forages (62.5%), vegetables (62.12%), and nuts (60.23%). Corn shows the largest update frequency among field crops, averaging 86.66%. Next come peanuts (79.22%), sorghum (78.64%), barley (76.36%), cotton (76.12%), rice (75.35%), wheat (74.81%), soybeans (73.06%), canola (72.8%), sunflowers (72.49%), sugar beets (71.87%), and oats (64.89%). These trends also vary considerably by state. Notably, crops such as fruits, nuts, and vegetables in states where they

[9] Although T-yields were employed under the assumption that they align reference yields more closely with the average yield of producers in the county, the old method overlooked the latency effect. This effect stemmed from the comprehensive T-Yield reviews conducted only every 4 to 5 years.

comprise a smaller share of total insured acreage tend to record lower rates of updates, underscoring the regional diversity in how actuarial parameters are revised across the program.

4. Counterfactual Simulation Design

The update percentages in Figures 2 and 3 highlight the FCIP's adaptive approach to maintaining accurate insurance premiums. This section presents a counterfactual simulation aimed at examining how these adjustments affect the program's fiscal outcomes. We define actuarial updates as routine, data-driven recalibrations to rating parameters (such as base rates, exponents, and reference yields) that occur as part of the FCIP's annual experience-rating cycle. These updates are not methodological innovations per se but are integral to maintaining actuarial soundness.

The simulation proceeds in two primary steps. First, it modifies the FCIP loss experience data from the current crop year, as recorded in the SOBTPU, to generate scenarios both with and without updated ADM parameters. The rationale for this design is that the RMA's annual rate-setting process explicitly excludes loss experience from the current year and the two preceding years when computing new rating parameters (see Figure S1 for a schematic). This three-year exclusion rule ensures that the parameters used to rate a given crop year's policies are based solely on lagged information, thereby preventing contemporaneous acreage or coverage decisions from influencing the rate-setting process. Consequently, contract selections and participation data for the current crop year can be treated as an out-of-sample test against two consecutive ADM datasets. For example, producer choices observed in 2019 can be used to compare the 2019 ADM with the 2018 ADM, noting that the 2019 loss experience was not incorporated into the development of either dataset. This temporal separation provides a natural identification mechanism that mitigates potential simultaneity between insured decisions and the rating parameters used in the simulation.

Key to the simulations is the assumption that farmer demand and behavior remain largely unchanged whether updates occur or not. Adverse selection is minimal (coverage levels are fixed but acres insured is not), and moral hazard is stable (yields and prices remain constant). While moral hazard can arise through input-use decisions (Smith and Goodwin 2017; Horowitz and Lichtenberg 1993; Yu and Hendricks 2020), studies suggest limited impact on yields (Coble et al. 1997; Babcock and Hennessy 1996; Quiggin et al. 1993; Mieno et al. 2018), which are mainly driven by weather and climate. Since 2000, drought and high temperatures account for 42% of FCIP indemnities, and excess moisture adds another 28%. These figures underscore the predominant role of weather in driving losses rather than shifts in production decisions. Furthermore, multiple studies suggest that premium subsidies in the FCIP have substantially reduced adverse selection (Tsiboe and Turner 2023; Coble and Barnett 2013; Just et al. 1999; Glauber 2013; Glauber 2004), while other research consistently finds relatively inelastic demand for coverage (Gardner and Kramer 1986; Barnett et al. 1990; Calvin 1990; Goodwin 1993; Goodwin and Kastens 1993; Hojjati and Bockstael 1988; Coble et al. 1996; Yi et al. 2020; Maisashvili et al. 2020; Bulut and Hennessy 2021). Recently estimated elasticities for producer-paid rates (-0.052 for acres insured and -0.022 for coverage level) demonstrate minimal response to one-year changes (Tsiboe and Turner 2023). This is especially apparent at the intensive margin, where premium rates must rise by over 20% to trigger a coverage-level switch. Since the FCIP generally limits year-to-year fluctuations in individual rates to around 20%, broad or rapid shifts in crop insurance demand, particularly with respect to coverage levels, are unlikely under current rate volatility.

Prior research on crop insurance demand elasticities typically combines the effects of rating parameter changes with producers' risk preferences. To distinguish the influence of parameter updates, this study regresses the annual percentage change in pool-level insured acreage on the annual percentage changes of selected rating parameters, controlling for pool and crop-year fixed effects. Two model variants, unconditional (each parameter tested separately) and conditional (all parameters tested together), are estimated over periods ending in 2024 (e.g., 2005-2024 to 2019-2024), using insurance pools that appear consistently each year. As shown in Figure S2, changes in rating parameters within a given year led to negligible shifts in insured acreage, regardless of parameter type, model specification, or time window.

Drawing on the literature and the regression findings shown in Figure S2, the simulations assume that only the extensive margin (insured acreage) changes in response to rating updates, while moral hazard (final yields and market prices) remains unchanged. This simplified yet robust approach offers a clear baseline for analyzing how ADM updates directly affect the program's finances. It also allows for systematic re-simulation when new data emerges, or greater complexity is introduced. By focusing on a well-defined framework, analysts can make incremental adjustments that enhance clarity and precision, ensuring reliable assessment of policy changes. Robustness checks based on the adjustment rules described in Note S1 are later performed that allow for constant demand, changes in demand at the intensive margin only (i.e., coverage level), and changes along both the extensive and intensive margins (i.e., insured acres and coverage level).

Building on these assumptions, the simulation starts by fixing each SOBTPU entry's insured acres (A_{ijt}), liability (L_{ijt}), indemnity (I_{ijt}), subsidy per dollar of premium (s_{ijt}), and calibrated rate yield ($\bar{y}_{ijt}$) [Equation (3)] at their observed values for the update year. Next, two premium rates are calculated for each entry: one with updated parameters (r^{b}_{ijt}) and one without (r^{a}_{ijt}). Formally,

$$r^{b}_{ijt} = \left[\alpha_{jt}\left(\bar{y}_{ijt}/\bar{y}_{cjt}\right)^{\beta_{jt}} + \delta_{jt}\right] F^{\theta_t}_{ijt} F^{u_t}_{ijt} \tag{4}$$

$$r_{ijt}^{a} = \left[\alpha_{jt-1}\left(\bar{y}_{ijt}/\bar{y}_{cjt-1}\right)^{\beta_{jt}} + \delta_{jt-1}\right] F_{ijt-1}^{\theta_t} F_{ijt-1}^{u_t} \qquad (5)$$

s.t $r_{ijt}^{b} \times 0.8 \leq r_{ijt}^{a} \leq r_{ijt}^{b} \times 1.2$ and $r_{ijt}^{k} \in (0,1), \forall k = a, b$

Parameters for the update scenario (r_{ijt}^{b}) come from the current year (t), while those for the no-update scenario (r_{ijt}^{a}) are from the previous year ($t-1$). The 20% range limit on (r_{ijt}^{a}) aligns with RMA guidelines.[10]

For the update scenario, the insured acres (A_{ijt}^{b}) directly reflect the observed values in the SOBTPU dataset. Given this observed value, the insured acreage for the no-update is calculated based on crop by crop years level estimated elasticities (e_{jt}) (see Figure S3) given the difference between update and no-update rates; $A_{ijt}^{a} = A_{ijt}^{b} * e_{jt}\left(\frac{r_{ijt}^{a}}{r_{ijt}^{b}} - 1\right) \times 100$. Similarly, while total liability (L_{ijt}^{b}), total premiums (P_{ijt}^{b}), subsidy amounts (S_{ijt}^{b}), and indemnities (I_{ijt}^{b}) for the update scenario is taken as given in the SOBTPU, the no-update case analogues are respectively calculated as; $L_{ijt}^{a} = \frac{L_{ijt}^{b} A_{ijt}^{a}}{A_{ijt}^{b}}$, $P_{ijt}^{a} = r_{ijt}^{a} L_{ijt}^{a}$, $P_{ijt}^{a} = \frac{P_{ijt}^{b} P_{ijt}^{a}}{S_{ijt}^{b}}$, and $I_{ijt}^{a} = \frac{I_{ijt}^{b} A_{ijt}^{a}}{A_{ijt}^{b}}$.

In the second phase of the simulation, the study recalculates the financial outcomes from Section 2 using the revised SOBTPU data for both the update and no-update scenarios. The results are aggregated by crop year to enable direct comparisons. A reduction in total fiscal outflows (comprising premium subsidy, indemnity payments, program delivery costs, and underwriting

[10] *The counterfactual 'no-update' scenario is a hypothetical construct designed solely to isolate the fiscal implications of these recalibrations, rather than to suggest that such updates could realistically be suspended in practice.*

gains) when moving from the no-update to the update scenario clearly indicates an improvement in the program's fiscal stability.

In the baseline scenario, the study models an update reflecting the current RMA update pattern, which implies a comprehensive simultaneous update to all four parameters (α, δ, β, and $\bar{y}_c$), whether on the same or staggered schedules. This scenario reflects what RMA did in terms of these updates, thus only the no-update state of the world is simulated whilst the up-to-date state is taken as the observed SOBTPU. By contrast, subsequent simulations focus on "targeted" updates, where only one parameter is allowed to change at a time, with the remaining parameters held at their values from the previous crop year. In these targeted scenarios, demand is adjusted accordingly for both states of the world. This design reveals how individual parameter changes influence the outcomes and highlights which specific updates carry the most potent impact.

Each scenario focuses on comparing updates versus no-updates solely for county-crop programs included in both the "incumbent" and "successor" ADM. As a result, any newly introduced or discontinued county-crop combinations are excluded, ensuring a valid basis for identifying whether a given parameter changed over time. This approach narrows the dataset to county-crop programs present consistently throughout the years studied, potentially underrepresenting areas with recent coverage expansions or contractions. Still, these continuously tracked county-crop combinations account for over 80% of the insured volume. Finally, each impact metric is calculated as the average of annual estimates from 2002 to 2024.

For statistical inference, standard errors are computed using a bootstrap approach with 100 replications. In each iteration, 648,610 insurance pools, defined by unique combinations of county, crop, crop type, and production practice, are sampled with replacement. Whenever a pool is chosen, every observation from its available crop years is included. After 100 rounds of sampling and simulations, the distribution of resulting estimates is used to derive standard errors.

5. Results and Discussions

This section presents the main findings of the simulation analysis. It begins by establishing a baseline scenario that reflects actuarial and fiscal outcomes under the assumption that no rating updates occurred during the 2002–2024 period. The subsequent analysis assesses the overall effects of actuarial updates by comparing this baseline to scenarios in which rating parameters were periodically revised. The discussion then turns to a comparison between targeted and comprehensive updates, highlighting differences in their relative impacts. Finally, the section examines temporal and spatial heterogeneity in outcomes across crop years and geographic regions, identifying areas where updates are most effective and where notable disparities persist.

5.1 Establishing the baseline

Table 3 presents the primary findings from the analysis across the full sample. Under the baseline "no update" scenario, the mean annual gross book of business was simulated at 167 million acres and $98 billion in liability. The simulated annual loss ratio of 0.787 is close to the program's official mean of 0.840 observed from 2001 to 2024. Fiscal inflows ($10.18 billion), comprising total premiums of $9.71 billion and underwriting losses of $0.47 billion, is lower than the official figures reported in Table 1. Similarly, the modeled fiscal outflows total $17.51 billion, broken down into a premium subsidy of $6.00 billion, indemnity payments of $7.47 billion, program delivery costs of $2.29 billion, and underwriting gains of $1.75 billion; these, too, are beneath the official values. Consequently, the overall direct cost of $7.33 billion is also lower than the official amounts. Two main factors explain these differences. First, the analysis only simulates the portion of the FCIP book of business related to plans rated under continuous rating, thereby excluding livestock, dollar plans, and area and index products that are incorporated in the official values of Table 1. Second, as premium rates have generally been declining in recent times, the baseline "no update" scenario (characterized by relatively high premium rates) results in a simulated decline in demand compared to official historical data.

5.2 The main effect

Table 3 offers a comprehensive comparison of the fiscal outcomes related to periodic actuarial updates in the FCIP over 2002–2024. The "baseline" (column 2) represents a scenario with no actuarial updates, while the alternative scenario uses the current RMA update pattern (column 3), with all results shown as percentage changes relative to the baseline. Almost every percentage change is statistically significant ($p < 0.01$), indicating that these differences are highly unlikely to be due to chance.

Under the update scenario, key metrics such as insured area and liability increase moderately by 0.25% and 0.15%, respectively, suggesting a modest expansion in the program's scope. At the same time, the loss ratio declines by 1.42%, reflecting improved underwriting and more accurate risk assessment.

Ensuring the actuarial soundness of the FCIP is essential to managing its escalating fiscal burden. When the premiums collected (both from farmers and government subsidies) accurately reflect the underlying risk, the program operates more efficiently, reduces taxpayer exposure, and maintains fairness in subsidy distribution. However, when rating parameters become outdated or fail to align with actual loss experience, costs to the government increase due to higher-than-expected indemnities, and opportunities for private insurers to transfer risk back to the public emerge.

Table 3 further breaks down fiscal flows into inflows and outflows. Regarding inflows, premium revenue experiences a modest reduction of 1%, whereas underwriting losses see a significant reduction of 32%. As a result, total inflows declined by 2.44%. On the expenditure side, premium subsidies and program delivery costs reduced slightly by 1% each, while indemnity payments rose by 0.22%. Notably, underwriting gains dropped dramatically by 51%, leading to an overall decline of 5.52% in total outflows. Cumulatively, these changes result in a significant reduction in the direct net cost to taxpayers, falling by 9.78% from a baseline of $7.33 billion.

5.3 Targeted vs comprehensive updates

Columns (4) through (7) of Table 3 present the effects of targeted updates to individual ADM parameters (reference rate, fixed rate, rating exponent, and reference yield) and reveal significant differences in their impact on net taxpayer cost. Specifically, updating only the reference rate reduces net taxpayer cost by 12.02%, while isolated updates to the fixed rate and rating exponent yield reductions of 11.43% and 10.67%, respectively. The most pronounced effect occurs when only the reference yield is updated, reducing net taxpayer cost by 13.13%. These findings underscore the disproportionate influence of certain parameters (particularly the reference yield) in shaping taxpayer liabilities and aligning premiums with actual loss experience.

In contrast, the current RMA approach, which applies simultaneous revisions to multiple rating parameters (either concurrently or on staggered schedules), yields smaller average cost reductions. This difference in impact stems from the interaction effects inherent in joint updates. Simultaneous adjustments may produce compensatory or offsetting effects among parameters, dampening the influence of any single correction. Targeted updates, by isolating specific components of the actuarial framework, more precisely calibrate premiums to expected losses, enhancing cost containment and fiscal efficiency—especially in cases where a particular parameter is misaligned with observed risk patterns.

This distinction is shaped by the broader regulatory context. The Federal Crop Insurance Act, under Section 508(d), requires that premium rates cover not only expected indemnities but also include a reasonable reserve margin for catastrophic losses. [11] This statutory requirement obligates RMA to balance actuarial soundness with financial resilience, often prompting the use of multi-parameter updates to address the diverse risk factors embedded in the program. Despite these complexities, RMA has consistently maintained a national average loss ratio of approximately 0.8 since 1997, indicating that collected premiums generally exceed indemnity payments by a sufficient margin to meet reserve targets [33].

These results contribute to ongoing policy discussions by demonstrating that while comprehensive updates support broad program stability, strategically targeted revisions—particularly to the reference yield—offer greater fiscal savings without compromising actuarial integrity. A hybrid approach that combines the consistency of comprehensive updates with the precision of targeted adjustments may yield the most effective outcome for future rate-setting practices.

[11] The FCIP, guided by Congressional mandates, requires that premium rates not only cover expected indemnities but also include a reasonable disaster reserve. This is articulated in the FCIP's utilization of a disaster reserve factor, which was set at 0.88 in 1991 based on historical data analysis from 1948-1988. The aim was to ensure financial stability 85% of the time across any 10-year period, leading to the inclusion of an additional 13.6% in the premium rates for disaster reserves. Despite statutory expectations for a loss ratio of 1.0, the practical adjustments and recalibrations of insurance parameters—often described as a 'whack-a-mole' problem—have resulted in RMA maintaining an average loss ratio closer to 0.8 since 1997, indicating a consistent performance above the target disaster reserve ratio. This information reflects the ongoing evaluation and adaptation of rating parameters to meet legislative and operational objectives.

5.4 Temporal and spatial heterogeneity

Figure 4 demonstrates substantial year-to-year variation in several fiscal measures of the FCIP attributable to rating parameter updates. When it comes to net taxpayer costs, while most years generated savings (evidenced by negative percentages) there are notable exceptions. Years like 2002 (1.69%) and 2005 (4.62%) show that updates in those periods increased taxpayer costs, possibly due to under-adjustment to emerging risks or overestimated revenue expectations. In contrast, certain years yielded substantial fiscal savings, with the most dramatic being 2016, where the update reduced taxpayer cost by 39.54%. Other strong-performing years include 2003 (–25.01%), 2017 (–19.63%), and 2021 (–15.87%). Moderate savings were common in years such as 2013, 2019, and 2023, with reductions between 1% and 7%. These temporal patterns suggest that the effectiveness of RMA updates in reducing taxpayer costs has been largely consistent over time. Periods of strong savings may reflect improvements in rating accuracy or better alignment with observed risk, while costlier years are tied to significant weather and market disruptions, lagged adjustments, or structural model limitations. Overall, this temporal heterogeneity highlights the importance of continuously refining actuarial practices and reinforces the case for incorporating more adaptive or targeted updates to maintain fiscal discipline within the FCIP.

Figure 5 demonstrates that when it comes to net taxpayer costs, most states fall within negative ranges, implying net savings to taxpayers relative to the baseline, although the specific extent of these savings differs widely. Agricultural states in the Midwest with a high FCIP footprint in terms of acres enrolled (such as Illinois, Indiana, Wisconsin, Ohio, Michigan, Iowa, Missouri, Nebraska, South Dakota, North Dakota, and Minnesota) tend to show notably negative values in excess of -10%, suggesting greater fiscal savings that may reflect more stable yields or more precise information for premium rate setting. In contrast, states like Alaska, Rhode Island, and New

Mexico feature positive ranges well above 5%, implying notably higher costs to taxpayers. These outliers often have smaller program footprints or more volatile production risks, which can magnify losses and drive-up government outlays. A few other states, such as Arkansas, North Carolina, Oklahoma, Louisiana, Texas, Utah, California, and Florida, also exhibit modest positive net costs (less than 5%), underscoring regional diversity in crop types, climatic conditions, and program participation. Overall, the state-level results highlight that crop insurance's fiscal impact depends on a complex interplay of factors (such as farm characteristics, climate risk, and underwriting parameters) and that improved targeting of actuarial practices could potentially moderate the extremes in cost variation across different regions.

5.5 Robustness checks

To assess the robustness of the simulation results, we evaluated how alternative demand assumptions and parameter adjustments influence the estimated fiscal outcomes. Figure S4 compares the fiscal impacts of actuarial updates under four demand scenarios: (i) constant demand, (ii) adjustments along the extensive margin (insured acreage) only, (iii) adjustments along the intensive margin (coverage level) only, and (iv) adjustments along both margins. The results show that insured area, liability, premium, and subsidy outcomes remain largely stable across all scenarios, confirming that the main findings are not sensitive to the demand specification. Divergence appears only in total indemnities when coverage levels vary, primarily due to the difficulty of recalculating indemnities using aggregated data. Applying the five adjustment rules described in Note S1, we find that using county-level yields and harvest prices as proxies systematically lowers indemnification rates and can slightly overstate fiscal savings. Overall, the specification that allows adjustments along the extensive margin only provides the most reliable baseline, and the central conclusion, that annual actuarial updates enhance fiscal soundness, remains robust across all alternative assumptions.

6. Conclusion

This study evaluated the fiscal impacts of updating rating parameters in the Federal Crop Insurance Program (FCIP) from 2002 to 2024. Using a counterfactual framework that compared a no-update baseline with scenarios featuring both the full RMA update pattern and targeted single-parameter revisions, the analysis shows that accurate, timely actuarial updates reduce taxpayer costs by roughly 10% per year. By aligning premiums more closely with realized loss experience, these updates strengthen fiscal stability and help prevent the buildup of net underwriting gains that would otherwise increase program outlays.

A central insight from the analysis is that not all rating parameters contribute equally to fiscal savings. Targeted, single-parameter updates, especially those involving high-leverage components such as the reference yield and rating exponent, produce larger cost reductions than holistic updates. The reference yield alone can reduce taxpayer costs by up to 13%. These findings highlight that the fiscal effectiveness of actuarial revisions depends on the information sensitivity of individual parameters. While comprehensive updates promote program-wide consistency and help satisfy statutory reserve requirements, simultaneous adjustments can dilute the influence of high-impact parameters when they move in offsetting directions. An adaptive rate-setting approach that prioritizes parameters with the greatest marginal contribution, while reserving full updates for periodic recalibration and compliance, may improve fiscal efficiency without compromising actuarial soundness.

The limited number of years (e.g., 2002, 2005) and states (e.g., Alaska, Rhode Island, New Mexico) in which annual updates did not generate savings further underscore the importance of heterogeneity in underlying risk environments. These exceptions likely reflect a combination of data sparsity, regional production volatility, and lagged actuarial adjustments. In states with small insured portfolios or highly variable conditions, parameter estimates are inherently less stable, increasing the likelihood of over- or under-adjustment. Similarly, extreme weather events, especially in coastal or climatically heterogeneous regions, can temporarily decouple expected and realized losses, reducing the measured fiscal gains from updates. These patterns suggest that while uniform national procedures promote consistency, more targeted monitoring or region-specific recalibration frequencies could help align updates with localized risk dynamics and strengthen the program's fiscal resilience.

Finally, although more frequently targeted actuarial updates can materially enhance fiscal precision, they also introduce important trade-offs. Rapid changes in rating parameters may increase short-term premium volatility, potentially influencing producer participation or perceptions of program stability. Existing FCIP guardrails, including limits on year-over-year rate changes, credibility smoothing, and the use of expert judgment during rate review, mitigate abrupt shifts, but producers may still perceive uncertainty when updates become more frequent. Targeted recalibrations also raise administrative complexity and place greater demands on communication and transparency to ensure producer trust. Without clear messaging, even well-designed updates may inadvertently encourage adverse selection or strategic coverage adjustments.

Taken together, these findings underscore that actuarial refinement must be balanced against operational feasibility, producer confidence, and regional heterogeneity in risk. Further empirical research, particularly on producer behavioral responses, premium volatility, and region-specific update performance, will be essential for designing update strategies that improve fiscal outcomes while sustaining program stability.

Despite the robustness of the results, several limitations warrant consideration and offer directions for future research. First, the analysis relies on aggregated county-level data and assumes that farmer behavior (particularly insured acreage and coverage decisions) remains largely unchanged in response to annual premium adjustments. This assumption isolates the fiscal effects of actuarial recalibrations but abstracts from dynamic behavioral responses that may evolve over multiple years as producers adjust to changing risk perceptions, crop rotations, or land-tenure arrangements. Second, the counterfactual simulations hold observed losses constant while varying actuarial parameters. This design clarifies the direct fiscal consequences of rating updates but does not capture potential feedback mechanisms through which premium changes could influence future production decisions, coverage levels, or loss experiences.

Third, while the analysis demonstrates that annual actuarial updates reduce taxpayer costs, it is important to note that these efficiency gains primarily reflect fiscal improvements rather than allocative efficiency. Given the limited behavioral responsiveness of insured acreage, the observed savings arise largely from mechanical differences in premium rates between updated and non-updated scenarios. In this sense, the results should be interpreted as evidence of enhanced fiscal soundness through more accurate pricing, rather than as a reflection of behavioral optimization or welfare improvement. Future research that integrates micro-level behavioral responses and welfare metrics would provide valuable insights into the allocative implications of actuarial recalibrations in the FCIP.

The analysis assumes that annual actuarial recalibrations occur within the existing operational framework of the RMA and does not explicitly account for the administrative or transition costs associated with implementing such updates. While RMA's annual appropriations are reported in the Appendix, publicly available data does not disaggregate these expenditures by activity, making it difficult to isolate the portion attributable to parameter updates. Consequently, the estimated fiscal savings should be interpreted as net of programmatic outcomes but not net of potential administrative costs related to rate maintenance.

Finally, the actuarial updates examined represent routine, data-driven recalibrations, such as adjustments to county base rates, fixed rates, rating exponents, and reference yields, rather than methodological or structural reforms to the actuarial framework of FCIP. Future work incorporating longitudinal, farm- or policy-level microdata and dynamic behavioral modeling would enable a richer assessment of how participation elasticity, welfare outcomes, and adaptive responses shape the long-term fiscal and allocative performance of the program.

In the broader context, the FCIP has long been a cornerstone of U.S. agricultural policy, operating as part of a public–private partnership that supports farmers and sustains domestic food production while contributing to macroeconomic stability. With taxpayer support averaging about $2.18 per month per American since 2008, optimizing program management through refined actuarial methodologies is essential. The findings underscore that focused adaptive updates not only reduce taxpayer liabilities and strengthen fiscal discipline but also ensure the efficient use of government funds. These insights provide valuable guidance for policymakers seeking to balance fiscal efficiency with robust support for the agricultural sector while maintaining a secure food supply.

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Tables and Figures

Table 1: Crop year Government cost of Federal Crop Insurance Program (2001-24)

Crop year	Total premium [A]	Premium subsidy [B]	Indemnities [C]	Program delivery cost [D]	UW Losses Paid by AIPs to FCIC [E1]	UW Gains Paid by FCIC to AIPs [E2]	Total direct cost [F= A -B-C-D+E1-E2]
	Billion 2024 US dollars						
2001	5.635	3.371	5.617	0.666	0.000	1.222	-5.239
2002	5.808	3.468	8.087	0.000	0.020	1.249	-6.975
2003	6.321	3.772	5.970	0.697	0.000	1.347	-5.464
2004	6.888	4.066	5.315	1.142	0.000	1.467	-5.103
2005	6.725	3.981	4.029	1.555	0.000	1.413	-4.253
2006	7.763	4.542	5.926	1.396	0.000	1.626	-5.727
2007	9.396	5.472	5.076	2.251	0.000	1.908	-5.312
2008	12.858	7.423	11.326	1.428	0.000	2.621	-9.939
2009	13.286	8.052	7.756	3.409	0.000	2.403	-8.334
2010	10.473	6.491	5.862	2.642	0.000	1.887	-6.410
2011	14.354	8.936	13.000	2.006	0.000	1.629	-11.217
2012	12.692	7.958	19.905	0.000	1.498	1.599	-15.272
2013	13.220	8.162	13.522	0.719	0.000	1.561	-10.745
2014	11.186	6.893	10.129	1.152	0.000	1.535	-8.523
2015	11.813	7.353	7.643	2.183	0.000	1.727	-7.094
2016	12.386	7.781	5.212	3.460	0.000	1.917	-5.984
2017	12.913	8.140	6.997	3.344	0.000	1.896	-7.464
2018	13.088	8.280	9.689	2.801	0.000	2.035	-9.717
2019	13.605	8.528	14.204	0.677	0.000	2.100	-11.905
2020	13.067	8.127	11.573	1.711	0.000	2.119	-10.464
2021	15.544	9.623	10.576	3.536	0.000	2.044	-10.235
2022	17.681	11.010	18.355	1.359	0.000	2.038	-15.082
2023	19.724	12.071	17.601	2.658	0.000	2.442	-15.049
2024	15.897	10.430	12.762	2.440	0.000	4.051	-13.786
Averages							
2001-2010	8.515	5.064	6.496	1.519	0.002	1.714	-6.276
2011-2024	14.084	8.807	12.227	2.003	0.107	2.050	-10.896
2001-2024	11.763	7.247	9.839	1.801	0.063	1.910	-8.971
	Average annual growth rate (%)						
2001-2010	8.219	8.519	9.175	16.327	-	6.149	7.055
2011-2024	3.941	4.266	13.965	21.078	-	6.866	9.307
2001-2024	5.615	5.930	12.091	19.268	-	6.585	8.426

Source: Compiled by authors, using data from USDA, Risk Management Agency as of 11/05/2025

This table includes standard livestock, Puerto Rico and is based on crop year. **Total premium** is comprised of producer paid premium and premium subsidy. **Premium subsidy** represents the subsidized portion of Total Premium. **Indemnities** are payments to Approved Insurance Providers (AIP) for insurable losses, sometimes called loss claims. **Program delivery costs** are payments to the AIPs to cover administrative and operating expenses associated with delivering the crop insurance program. **Underwriting gains** represent the AIP portion of the earnings on the insurance book of business. If the insurance book of business is a loss, AIP would pay FCIC for their portion of the **Underwriting losses**. **Total direct** costs are all costs associated with the crop insurance program.

Table 2: Means and Standard Deviations of US Federal Crop Insurance Outcomes (2001-24).

Variables	Full sample	Corn	Soybeans	Wheat	Cotton	Sorghum	Barley	Rice
Summary of business outcomes								
Coverage level (%)	0.73 (0.08)	0.75 (0.07)	0.74 (0.08)	0.70 (0.07)	0.67 (0.08)	0.68 (0.07)	0.71 (0.07)	0.68 (0.11)
Net insured area (acres)	1280 (4306)	1532 (4892)	1453 (4598)	1398 (4966)	1130 (3388)	714 (1948)	671 (1726)	935 (1858)
Total insured liability ($ 1,000)	482 (2132)	786 (3152)	497 (1834)	242 (1054)	420 (1417)	120 (385)	104 (298)	642 (1941)
Total premium ($ 1,000)	49.08 (211.69)	70.18 (281.86)	43.73 (164.56)	39.36 (173.57)	77.47 (340.85)	24.85 (82.21)	13.67 (40.38)	40.44 (115.51)
Total subsidy ($ 1,000)	30.35 (142.56)	43.07 (190.85)	26.96 (109.73)	24.27 (110.55)	51.22 (245.52)	15.73 (55.41)	8.33 (26.62)	24.95 (70.49)
Total indemnity ($ 1,000)	41.91 (310.52)	55.67 (397.17)	27.31 (151.19)	36.42 (230.28)	101.69 (668.13)	24.82 (136.73)	12.27 (54.46)	74.88 (584.60)
Premium per dollar of liability	0.14 (0.11)	0.11 (0.09)	0.11 (0.09)	0.16 (0.11)	0.19 (0.14)	0.23 (0.15)	0.16 (0.10)	0.08 (0.06)
Subsidy per dollar of premium	0.61 (0.10)	0.61 (0.10)	0.61 (0.11)	0.61 (0.09)	0.64 (0.09)	0.62 (0.08)	0.60 (0.09)	0.60 (0.13)
Producer paid premium rate	0.05 (0.05)	0.05 (0.04)	0.05 (0.04)	0.06 (0.05)	0.07 (0.06)	0.09 (0.06)	0.06 (0.05)	0.03 (0.03)
Actuarial data master outcomes								
Reference rate	0.03 (0.02)	0.03 (0.02)	0.02 (0.01)	0.03 (0.02)	0.03 (0.01)	0.04 (0.02)	0.03 (0.02)	0.02 (0.01)
Fixed rate	0.11 (0.09)	0.08 (0.07)	0.09 (0.08)	0.11 (0.08)	0.16 (0.12)	0.17 (0.12)	0.12 (0.08)	0.03 (0.02)
Rating exponent	-1.39 (0.57)	-1.40 (0.57)	-1.58 (0.44)	-1.50 (0.49)	-1.04 (0.37)	-1.40 (0.58)	-1.40 (0.50)	-1.25 (0.63)
Coverage level differential factor-50%	0.66 (0.11)	0.66 (0.11)	0.63 (0.11)	0.67 (0.11)	0.71 (0.12)	0.68 (0.12)	0.70 (0.11)	0.74 (0.10)
Coverage level differential factor-55%	0.77 (0.12)	0.76 (0.11)	0.73 (0.11)	0.77 (0.11)	0.80 (0.13)	0.77 (0.13)	0.79 (0.11)	0.83 (0.10)
Coverage level differential factor-60%	0.85 (0.11)	0.85 (0.11)	0.83 (0.10)	0.86 (0.12)	0.87 (0.13)	0.85 (0.13)	0.87 (0.11)	0.89 (0.09)
Coverage level differential factor-65%	0.95 (0.11)	0.95 (0.11)	0.96 (0.11)	0.95 (0.12)	0.95 (0.12)	0.94 (0.14)	0.96 (0.11)	0.97 (0.08)
Coverage level differential factor-70%	1.08 (0.12)	1.08 (0.11)	1.11 (0.13)	1.06 (0.11)	1.05 (0.11)	1.04 (0.12)	1.06 (0.10)	1.07 (0.09)
Coverage level differential factor-75%	1.22 (0.14)	1.22 (0.13)	1.30 (0.17)	1.18 (0.12)	1.16 (0.10)	1.17 (0.11)	1.18 (0.09)	1.19 (0.12)
Coverage level differential factor-80%	1.38 (0.20)	1.37 (0.16)	1.53 (0.23)	1.32 (0.14)	1.29 (0.12)	1.33 (0.12)	1.32 (0.10)	1.34 (0.17)
Coverage level differential factor-85%	1.56 (0.28)	1.55 (0.22)	1.79 (0.32)	1.46 (0.19)	1.44 (0.18)	1.50 (0.17)	1.47 (0.14)	1.52 (0.24)
Basic unit differential factor	1.03 (0.03)	1.03 (0.03)	1.03 (0.03)	1.04 (0.02)	1.05 (0.02)	1.03 (0.02)	1.05 (0.02)	1.04 (0.02)
Enterprise unit differential factor	1.01 (0.03)	1.00 (0.04)	0.99 (0.04)	1.02 (0.01)	1.03 (0.01)	1.01 (0.01)	1.03 (0.01)	1.02 (0.01)
Number of insurance pools	648,610	133,526	180,433	125,861	31,438	32,582	23,188	9,437
Number of observations	3,783,753	1,075,063	1,017,540	700,261	211,006	167,232	86,579	43,074

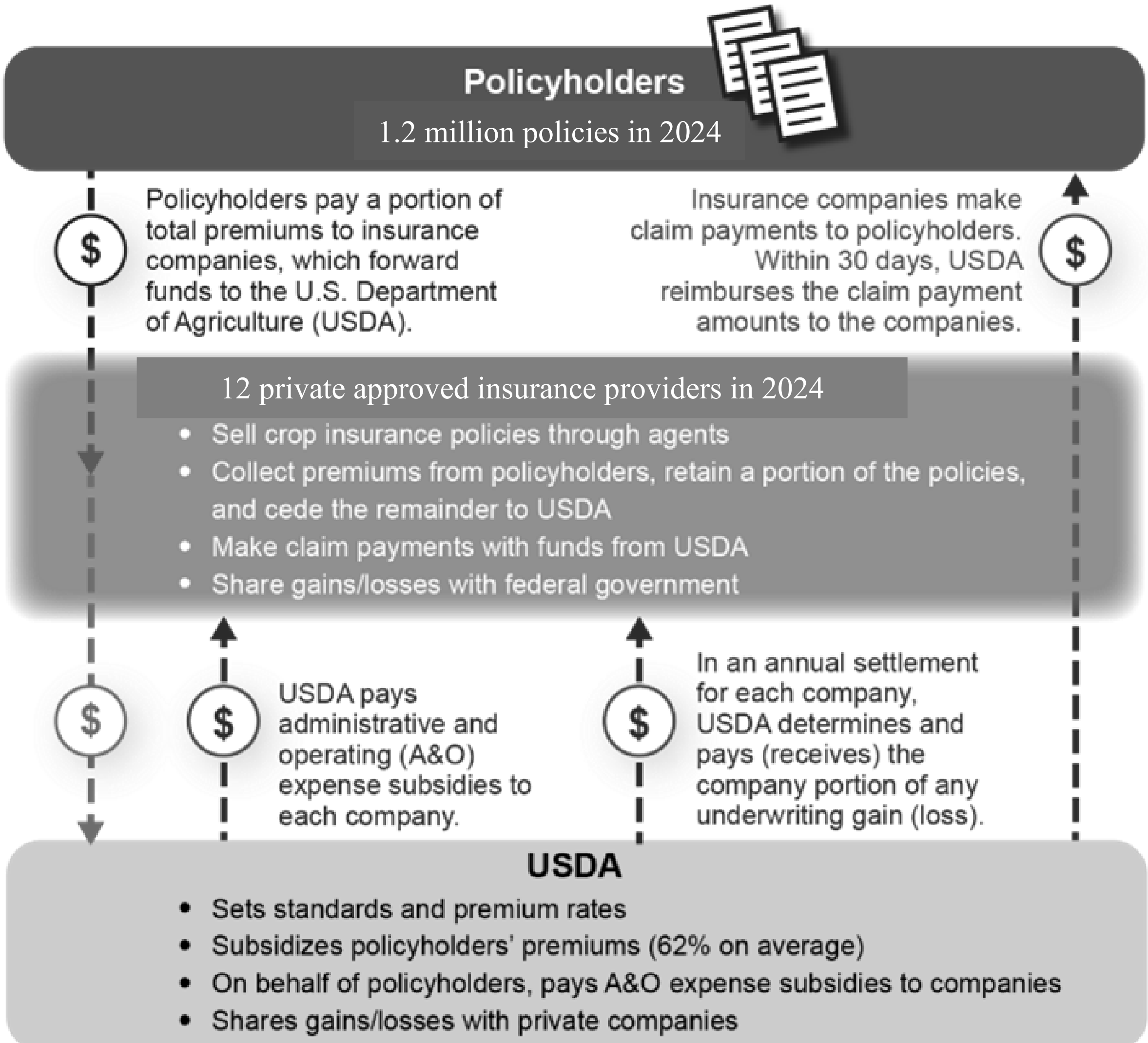
The data was constructed by the authors using primary data from (1) Risk Management Agency's summary of business and actuarial data master files that contain insurance metrics aggregated by county, crop, crop type, production practice, insurance plan, coverage level, and insurance unit.

Table 3: Fiscal impacts of actuarial updates in the United States Federal Crop Insurance Program (2002-24)

	Assumed no update (baseline)	Type of actuarial data master parameter update				
		Current RMA update pattern	Assumed Reference rate only updated	Assumed Reference fixed rate only updated	Assumed Rating exponent only updated	Assumed Reference yield only updated
Gross book of business		Expressed as percentage change over no update case				
Area insured (million acres)	167.187 (3.543)	0.246*** (0.069)	0.157*** (0.038)	0.197*** (0.047)	0.066** (0.032)	-0.182*** (0.036)
Liability (billion $)	98.206 (2.593)	0.150 (0.103)	0.154*** (0.057)	0.055 (0.060)	0.090* (0.047)	-0.162*** (0.041)
Loss ratio	0.787 (0.007)	-1.421*** (0.077)	-0.729*** (0.051)	-1.194*** (0.044)	-0.417*** (0.019)	0.795*** (0.022)
Fiscal inflows (billion $)						
Premium	9.711 (0.211)	-1.029*** (0.095)	-0.697*** (0.054)	-0.992*** (0.054)	-0.416*** (0.053)	0.991*** (0.043)
Underwriting losses	0.465 (0.020)	-31.939*** (2.336)	-44.135*** (2.275)	-38.817*** (2.594)	-52.529*** (1.279)	-70.823*** (1.570)
Total inflows	10.176 (0.222)	-2.442*** (0.148)	-2.684*** (0.139)	-2.721*** (0.131)	-2.800*** (0.126)	-2.294*** (0.157)
Fiscal outflows (billion $)						
Premium subsidy	6.004 (0.132)	-1.042*** (0.087)	-0.683*** (0.047)	-1.055*** (0.055)	-0.351*** (0.045)	0.987*** (0.038)
Indemnity	7.469 (0.174)	0.222 (0.210)	0.060 (0.107)	0.074 (0.113)	0.102 (0.066)	-0.019 (0.040)
Program delivery cost	2.285 (0.050)	-0.946*** (0.095)	-0.629*** (0.055)	-0.916*** (0.055)	-0.411*** (0.051)	0.926*** (0.047)
Underwriting gains	1.752 (0.044)	-51.261*** (1.015)	-63.012*** (0.593)	-59.133*** (0.557)	-59.627*** (0.577)	-72.768*** (1.335)
Total outflows	17.511 (0.381)	-5.515*** (0.193)	-6.596*** (0.111)	-6.367*** (0.120)	-6.097*** (0.116)	-6.831*** (0.183)
Net total direct cost to taxpayers (billion $)	7.334 (0.164)	-9.779*** (0.496)	-12.024*** (0.394)	-11.425*** (0.400)	-10.672*** (0.385)	-13.125*** (0.573)

Simulation: Actuarial Data Master [ADM] (successor) for the release year (e.g., 2023) was replaced with the ADM for the previous year (incumbent) (e.g., 2022) and the premiums were recalculated for the actual loss experience outcomes associated with the successor in the release year. Crop insurance demand at the extensive margin (insured acres) is allowed to shift based on responsiveness to paid premium rates.
Significance levels - *p<0.1 ** p<0.05, ***p<0.01. Standard errors in parentheses are estimated by resampling insurance pools 100 times.

Figure 1. Overview of Entities Involved in the United States Federal Crop Insurance Program Implementation



Source: Updated by author given U.S. Government Accountability Office (U.S. GAO) adaptation from the Congressional Research Services, and analysis of USDA, Risk Management Agency (RMA) data and documents.

Notes: The federal crop insurance program (FCIP) is implemented as a public-private partnership. Farmer/rancher policyholders work with insurance agents to purchase crop insurance policies sold by private sector insurers, known as Approved Insurance Providers (AIPs). When farmers file claims on the insurance policies, AIPs hire loss adjustors to determine the extent of losses incurred by the farmers. USDA provides reinsurance to AIPs for a portion of the losses from crop insurance policies sold. AIPs may purchase additional reinsurance from third-party reinsurers. USDA also regulates the policies sold by AIPs, subsidizes farmer premiums, and subsidizes AIPs for the cost of selling and servicing crop insurance policies.

Figure 2: Annual variation in actuarial updates in the United States Federal Crop Insurance Program (2002-24)

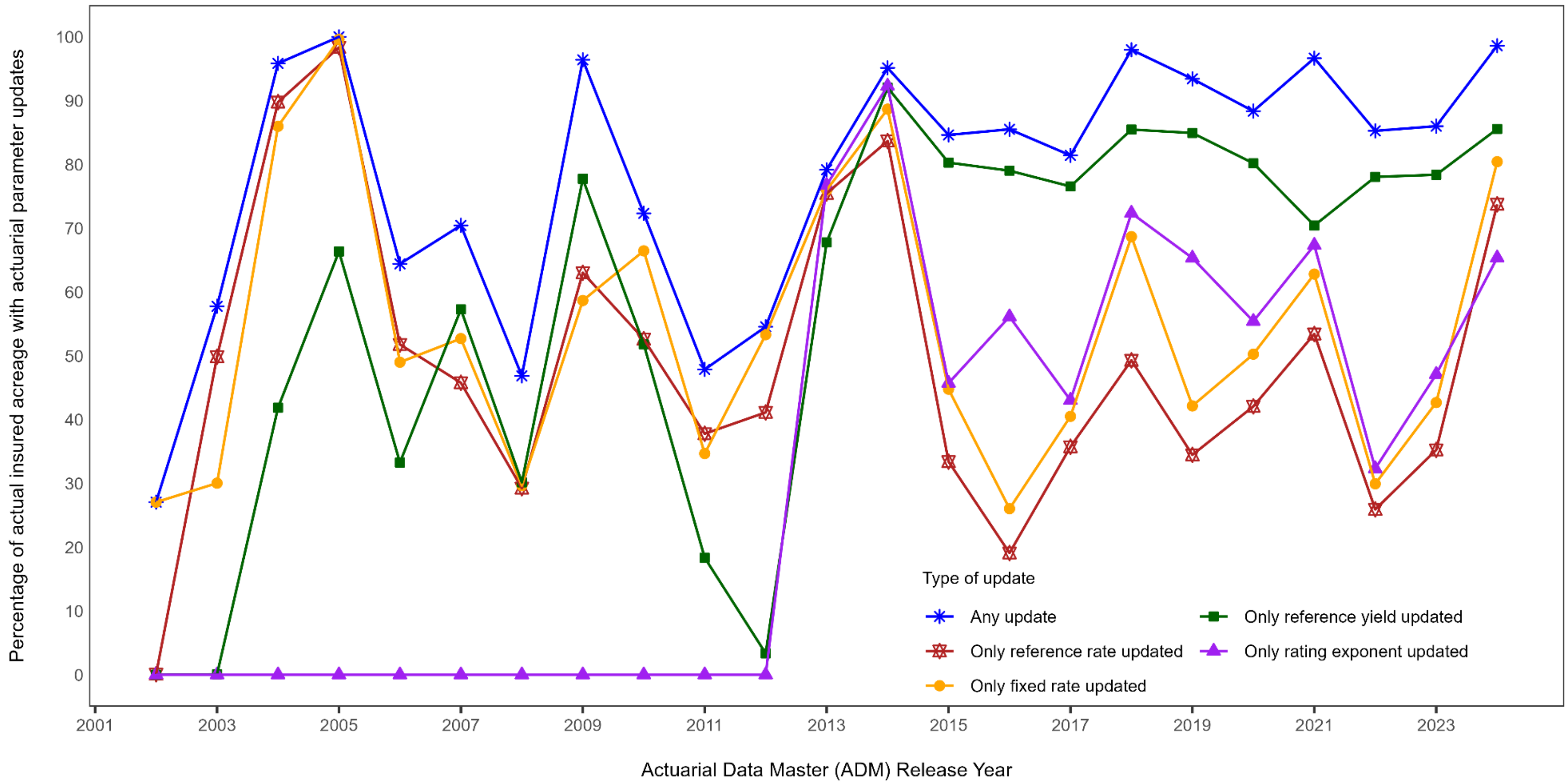


Figure 3: Variation in annual actuarial updates in the United States Federal Crop Insurance Program by state and commodity grouping (2002-24).

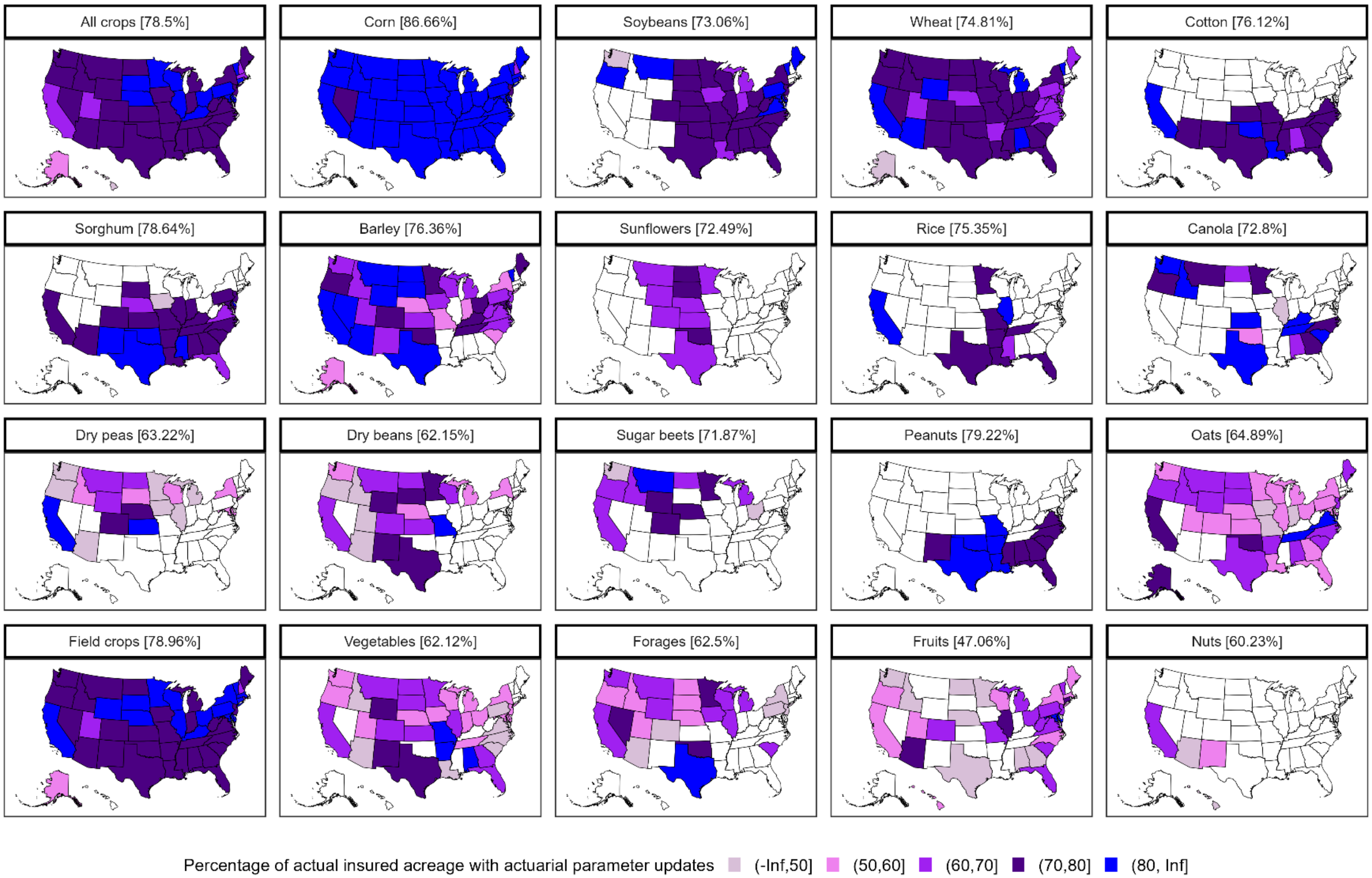


Figure 4: Temporal variation in the impacts of actuarial updates on the fiscal landscape of the United States Federal Crop Insurance Program (2002-24)

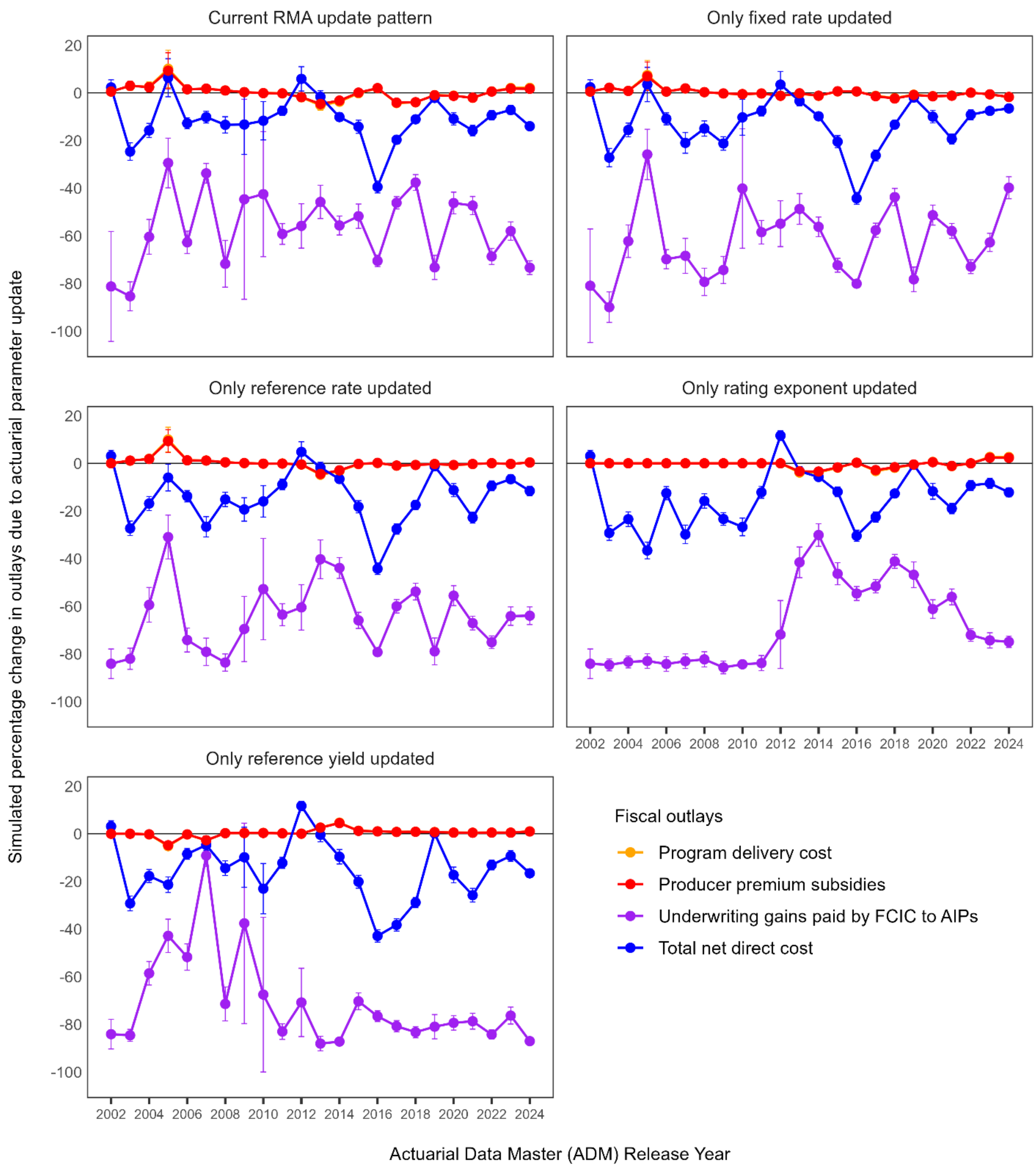
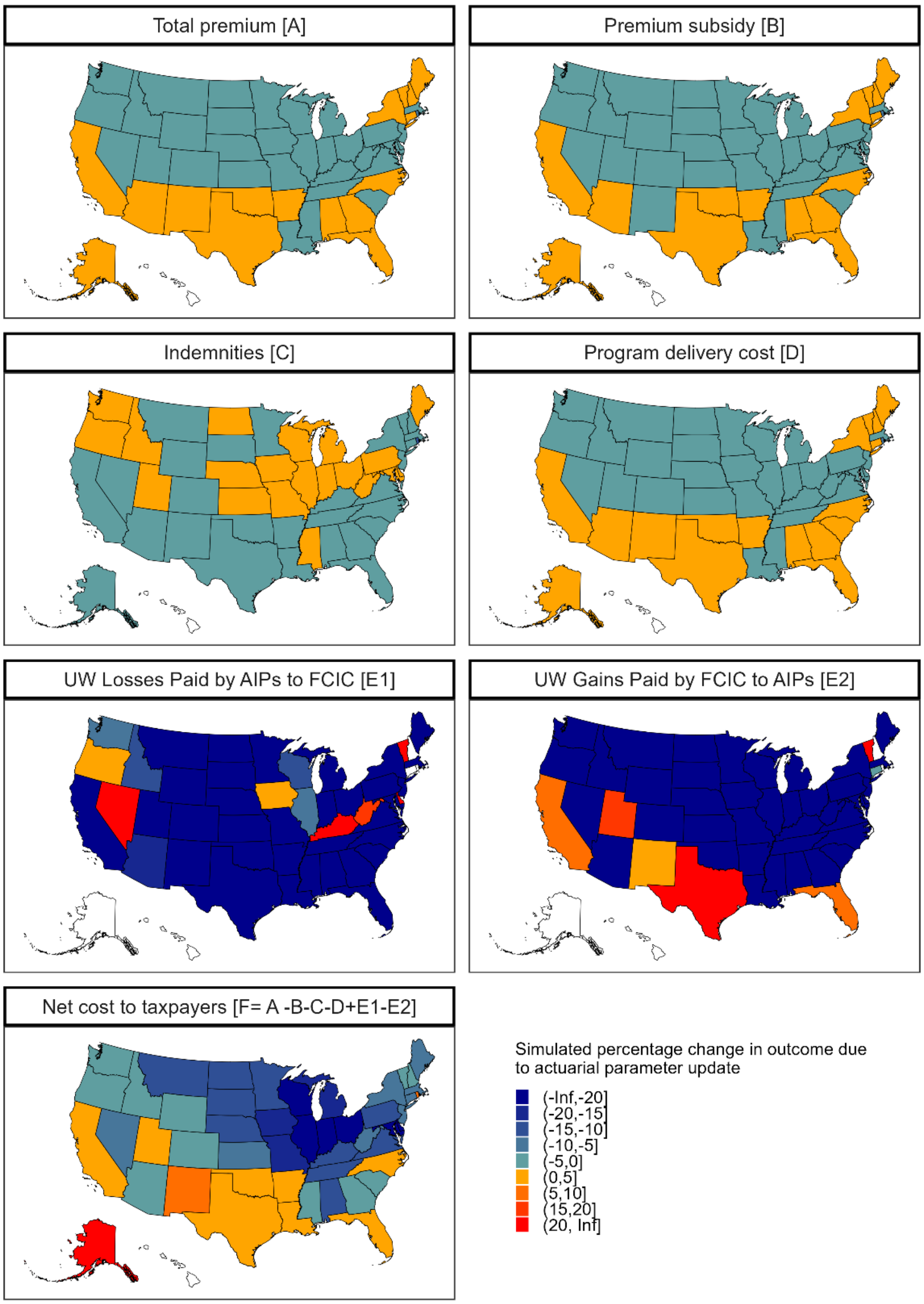


Figure 5: Fiscal impacts of actuarial updates in the United States Federal Crop Insurance Program by state (2002-24).



Appendix

Note S1: Adjustment Rules for Liability and Indemnities under Alternative Demand Scenarios

This note outlines the procedure used to adjust liability and indemnities when insured acreage or coverage levels are allowed to vary under alternative demand assumptions. These adjustments ensure internal consistency between actuarial parameters, coverage choices, and fiscal outcomes in the counterfactual simulations.

Liability Adjustment

When coverage levels differ between the baseline and simulated scenarios, liability per acre was adjusted proportionally as:

$$\text{New liability per acre } = \text{Old liability per acre} \times \frac{\text{New coverage level}}{\text{Old coverage level}}$$

This maintains the proportional relationship between coverage and insured value while holding yield and price expectations constant.

Indemnity Adjustments

Indemnity payments were modified based on five conditional cases reflecting different coverage and loss situations:

Case	**Baseline Condition**	**Adjustment Rule**	**Interpretation**
(1)	Higher coverage in simulated year; no baseline indemnity	Indemnity = 0	No loss realized in baseline; remains unchanged.
(2)	Higher coverage in simulated year; baseline indemnity > 0	Indemnity = Baseline indemnity × (New liability / Old liability)	Indemnity reduced proportionally to change in liability.
(3)	Same coverage level	Indemnity = Baseline indemnity	Retains observed indemnity.
(4)	Lower coverage in simulated year; baseline indemnity > 0	Indemnity = Adjusted liability per acre − Production-to-count per acre	Reflects lower protection relative to realized yield.
(5)	Lower coverage in simulated year; no baseline indemnity	Indemnity = Adjusted liability per acre − Revenue per acre	Accounts for newly exposed shortfall under reduced coverage.

Because policy-level production-to-count and revenue data are unavailable, county-level historical yields and harvest prices from the RMA were used as proxies. This approximation may underestimate indemnification rates in scenarios involving coverage changes, leading to slightly lower outlay estimates and thus a modest overstatement of cost savings. Figure S4 in the Supplementary Materials illustrates the resulting fiscal impacts across demand assumptions.

Table S1: United States Department of Agriculture, Risk Management Agency Appropriations

Fiscal year	Appropriations
2001	$67,700,000
2002	$74,752,000
2003	$76,062,000
2004	$78,488,000
2005	$91,582,000
2006	$87,806,000
2007	$80,797,000
2008	$79,062,000
2009	$77,177,000
2010	$80,325,000
2011	$83,064,000
2012	$82,325,000
2013	$74,900,000
2014	$71,496,000
2015	$76,779,000
2016	$76,946,000
2017	$66,615,000
2018	$55,000,000
2019	$37,942,000
2020	$56,045,000
2021	$59,440,000
2022	$69,207,000
2023	$75,443,000
2024	$77,897,000
Averages	
2001-2010	$79,375,100
2011-2024	$68,792,786
2001-2024	$73,202,083
Average annual growth rate (%)	
2001-2010	1.522
2011-2024	1.225
2001-2024	1.349

Source:

Table S2: Crop Insurance Annual Mean Subsidy as a Percent of Total Premium From 2000-24

Insurance plan and unit type	**Coverage level**										
	CAT	**50%**	**55%**	**60%**	**65%**	**70%**	**75%**	**80%**	**85%**	**90%**	**95%**
Individual yield and revenue plans											
Basic/Optional unit	100%	67%	64%	64%	59%	59%	55%	48%	38%	-	-
Enterprise unit	-	76%	75%	75%	73%	73%	70%	62%	48%	-	-
Group based plans											
Yield protection	100%	-	-	-	-	59%	59%	55%	55%	51%	-
Revenue protection	-	-	-	-	-	59%	55%	55%	49%	44%	-
Margin protection	-	-	-	-	-	59%	55%	55%	49%	44%	44%
Rainfall or vegetative index insurance	100%	-	-	-	-	59%	58%	54%	51%	51%	-
Supplemental plans											
Enhanced Coverage Option (ECO)	-	-	-	-	-	-	-	-	-	48%	48%
Supplemental Coverage Option (SCO)	-	65%	65%	65%	65%	65%	65%	65%	65%	-	-
Stacked Income Protection Plan (STAX)	-	-	-	-	-	-	80%	80%	80%	80%	-
Hurricane Insurance Protection - Wind Index (HIP-WI)	-	-	-	-	-	-	-	-	-	-	65%
Post-Application Coverage Endorsement (PACE)											
Basic/Optional unit	-	-	-	-	-	-	55%	48%	38%	38%	-
Enterprise unit	-	-	-	-	-	-	61%	53%	42%	42%	-
Livestock plans											
Dairy Revenue Protection	-	-	-	-	-	59%	55%	55%	49%	44%	44%
Whole farm protection plans	-	76%	75%	75%	73%	73%	72%	71%	56%	-	-

Source: Author using data from RMA Actuarial data master database

Notes: CAT = catastrophic. A basic unit covers land in one county with the same tenants and landlords. An optional unit is a basic unit divided into small units by township section. An enterprise unit (EU) covers all land of a single crop in a county for a producer, regardless of tenant and landlord arrangements. EU can also be specified by practice or type as allowed by the crop provisions, and they can also be multicounty. Individual plans (yield or revenue) are based on the on-farm production experience of the producer.

Table S3: Crop Insurance Administrative & Operating (A&O) Subsidy Schedule From 2000-24

Insurance plan	Coverage level									
	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
Basic Individual Plans										
Yield Protection	22-24%	22-24%	22-24%	22-24%	22-24%	22-24%	22-24%	22-24%	-	-
Revenue Protection	18-23%	18-23%	18-23%	18-23%	18-23%	18-23%	18-23%	18-23%	-	-
Revenue Prot with Harvest Price Exclusion	22-24%	22-24%	22-24%	22-24%	22-24%	22-24%	22-24%	22-24%	-	-
Actual Production History	22-27%	22-27%	22-27%	22-27%	22-27%	22-27%	22-27%	22-27%	-	-
Actual Production History - Price Component	22-24%	22%	22%	22-24%	22%	22%	-	-	-	-
Actual Revenue History	22-27%	22-27%	22-27%	22-27%	22-27%	22-27%	22-24%	22-24%	-	-
Production Revenue History - Yield	22-24%	22-24%	22-24%	22-24%	22-24%	22-24%	22-24%	22-24%	-	-
Production Revenue History - Plus	22-24%	22%	22-24%	22-24%	22-24%	22-24%	22-24%	22-24%	-	-
Production Revenue History - Revenue	22%	22%	22-24%	22%	22-24%	22-24%	22%	22-24%	-	-
Pecan Revenue	22-27%	22-27%	22-27%	22-27%	22-27%	22-27%	22-24%	22-24%	-	-
Revenue Assurance	-	-	-	27%	27%	27%	27%	27%	-	-
Tobacco (Guaranteed Production)	27%	27%	27%	27%	27%	27%	27%	27%	-	-
Tobacco (Quota)	27%	27%	27%	27%	27%	27%	-	-	-	-
Peanuts	27%	27%	27%	27%	27%	27%	-	-	-	-
Income Protection	27%	27%	27%	27%	27%	27%	27%	27%	-	-
Crop Revenue Coverage	27%	27%	27%	27%	27%	27%	27%	27%	-	27%
Grower Yield Certification	27%	27%	27%	27%	27%	27%	27%	27%	-	-
Whole Farm Revenue Protection	27%	27%	27%	27%	27%	27%	27%	27%	-	-
Avocado Revenue Coverage	27%	27%	27%	27%	27%	27%	-	-	-	-
Grower Yield Certification Span	27%	27%	27%	27%	27%	27%	-	-	-	-
Basic Group Plans										
Area Yield Protection	-	-	-	12-20%	12-20%	12-20%	12-20%	12-20%	12-20%	-
Area Revenue Protection	-	-	-	-	12-20%	12-20%	12-20%	12-20%	12-20%	-
Area Revenue Protection - Harvest Price Exclusion	-	-	-	-	12-20%	12-20%	12-20%	12-20%	12-20%	-
Group Risk Plan	-	-	-	18%	18%	18%	18%	18%	18%	-
Group Risk Income Protection - Harvest Revenue Option	-	-	-	-	20%	20%	20%	20%	20%	-
Group Risk Income Protection	-	-	-	-	18-27%	18-27%	18-27%	18-27%	18-27%	-
Group Risk Protection	-	-	-	25%	25%	25%	25%	25%	25%	-
Dollar Amount of Insurance	22-27%	22-27%	22-27%	22-27%	22-27%	22-27%	22-27%	22-27%	-	-
Fixed Dollar Amount of Insurance	22-27%	22-27%	22-27%	22-27%	22-27%	22-27%	22-27%	22-27%	-	-
Yield Based Dollar Amount of Insurance	22-27%	22-27%	22-27%	22-27%	22-27%	22-27%	22-27%	22-27%	-	-
Tree Based Dollar Amount of Insurance	22-27%	22-27%	22-27%	22-27%	22-27%	22-27%	-	-	-	-
Indexed Income Protection	27%	27%	27%	27%	27%	27%	27%	27%	-	-
Aquaculture Dollar	22-27%	22-27%	22-27%	22-27%	22-27%	22-27%	-	-	-	-
Rainfall Index	-	-	-	20-24%	20-27%	20-27%	20-27%	20-27%	20-27%	-
Vegetation Index	-	-	-	-	20-27%	20-27%	20-27%	20-27%	24-27%	-
Actual Production History - Indexed	27%	27%	27%	27%	27%	27%	-	-	-	-
Basic Livestock Plans										
Livestock Gross Margin	-	-	-	-	-	-	27%	27%	27%	27%
Dairy Revenue Protection	-	-	-	-	-	-	27%	27%	27%	27%
Basic or Endorsement										
Stacked Income Protection Plan - Revenue Protection	-	-	-	-	-	20-24%	20-24%	20-24%	20-24%	-
Stacked Income Protection Plan - Revenue Protection with Harvest Price Exclusion	-	-	-	-	-	20-24%	20-24%	20-24%	20-24%	-
Margin Protection	-	-	-	-	20-24%	20-24%	20-24%	20-24%	20-24%	20-24%
Margin Protection with Harvest Price Option	-	-	-	-	20-24%	20-24%	20-24%	20-24%	20-24%	20-24%
Endorsement										
Supplemental Coverage Option - Yield Protection	20-24%	20-24%	20-24%	20-24%	20-24%	20-24%	20-24%	20-24%	-	-
Supplemental Coverage Option - Revenue Protection	20-24%	20-24%	20-24%	20-24%	20-24%	20-24%	20-24%	20-24%	-	-

Supplemental Coverage Option - Revenue Protection with Harvest Price Exclusion	20-24%	20-24%	20-24%	20-24%	20-24%	20-24%	20-24%	20-24%	-	-
Enhanced Coverage Option - Yield Protection	-	-	-	-	-	-	-	-	20-24%	20-24%
Enhanced Coverage Option - Revenue Protection	-	-	-	-	-	-	-	-	20-24%	20-24%
Enhanced Coverage Option - Revenue Protection with Harvest Price Exclusion	-	-	-	-	-	-	-	-	20-24%	20-24%
Hurricane Insurance Protection - Wind Index	-	-	-	-	-	-	-	-	-	20-24%
Post-Application Coverage Endorsement - Yield Protection	-	-	-	-	-	22%	22%	22%	22%	-
Post-Application Coverage Endorsement - Revenue Protection	-	-	-	-	-	22-24%	22-24%	22-24%	22-24%	-
Post-Application Coverage Endorsement - Revenue Protection w Harvest Price Exclusion	-	-	-	-	-	22%	22%	22%	22-24%	-

Source: Author using data from RMA Insurance control elements database

Table S4: Shares of Underwriting Gains and Losses to Insurance Companies under the Standard Reinsurance Agreement 1998-24

	Assigned Risk Fund (ARF)	**Developmental Fund (DF)**			**Commercial Fund (CF)**		
		CAT	**REV**	**OTHER**	**CAT**	**REV**	**OTHER**
Panel A 1998-2011 reinsurance years							
Proportional reinsurance [a]							
Fund allocation	State max of 10-75%	All non- ARF designations			All non- ARF or -DF designations		
Retention within fund	20%	35-100% in 5% increment			50%-100% in 5% increment		
Non-proportional reinsurance [b]							
Percentage of loss on retained interest by loss ratio							
1.0–1.6	5.0	25.0	30.0	25.0	50.0	57.0	50.0
1.6–2.2	4.0	20.0	22.5	20.0	40.0	43.0	40.0
2.2–5.0	2.0	11.0	11.0	11.0	17.0	17.0	17.0
>5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Percentage of gain on retained interest by Loss ratio							
0.65–1.0	15.0	45.0	60.0	60.0	75.0	94.0	94.0
0.5–0.65	9.0	30.0	50.0	50.0	50.0	70.0	70.0
<0.5	2.0	4.0	6.0	6.0	8.0	11.0	11.0
Panel B: 2012-2024 reinsurance years							
Proportional reinsurance							
Fund allocation	State max of 75%				At least 25%		
Retention within fund	20%				35%-100% in 5% increment		
Non-proportional reinsurance [b, c]							
Percentage of loss on retained interest by loss ratio							
1.0–1.6	7.5	-	-	-	65.0 [42.5]	65.0 [42.5]	65.0 [42.5]
1.6–2.2	6.0	-	-	-	45.0 [20.0]	45.0 [20.0]	45.0 [20.0]
2.2–5.0	3.0	-	-	-	10.0 [5.0]	10.0 [5.0]	10.0 [5.0]
>5.0	0.0	-	-	-	0.0 [0.0]	0.0 [0.0]	0.0 [0.0]
Percentage of gain on retained interest by Loss ratio							
0.65–1.0	22.5	-	-	-	76.0 [97.5]	76.0 [97.5]	76.0 [97.5]
0.5–0.65	13.5	-	-	-	40.0 [40.0]	40.0 [40.0]	40.0 [40.0]
<0.5	3.0	-	-	-	5.5 [5.5]	5.5 [5.5]	5.5 [5.5]

CAT = Catastrophic insurance; REV=Revenue insurance plans; OTHER = All other crop insurance plans.

[a] After all reinsurance cessions, the AIP's must retain a percentage of net book premium and associated liability that equals or exceeds 35% of its book of business. If not, the AIP's retention of net book premium and associated liability for ultimate net losses for all contracts designated in the Assigned Risk Fund in all States will be increased on a pro rata basis to make the API's retention meet the minimum retention requirement.

[b] Share of loss or gain is determined incrementally by the realized loss ratio for a company's business in each state and fund

[c] The Percentage of loss/gain on retained interest by loss ratio for the Commercial Fund varied by three state grouping where the values in the bracket are for groups 2 and 3. "State Group 1" means Illinois, Indiana, Iowa, Minnesota, and Nebraska. "State Group 2" means Alabama, Arizona, Arkansas, California, Colorado, Florida, Georgia, Idaho, Kansas, Kentucky, Louisiana, Michigan, Missouri, Mississippi, Montana, North Carolina, North Dakota, New Mexico, Ohio, Oklahoma, Oregon, South Carolina, South Dakota, Tennessee, Texas, Virginia, Washington, and Wisconsin. "State Group 3" means Alaska, Connecticut, Delaware, Hawaii, Maine, Massachusetts, Maryland, Nevada, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Utah, Vermont, West Virginia, and Wyoming.

Table S5: Means and Standard Deviations of US Federal Crop Insurance Outcomes by Commodity (2001-24).

Variables	DRY BEANS	SUNFLOWERS	DRY PEAS	CANOLA	Field crops	Vegetables	Forages	Fruits	Nuts
Summary of business outcomes									
Coverage level (%)	0.69 (0.06)	0.69 (0.06)	0.69 (0.07)	0.71 (0.05)	0.73 (0.08)	0.69 (0.07)	0.60 (0.09)	0.62 (0.09)	0.67 (0.08)
Net insured area (acres)	509 (1361)	723 (1696)	825 (1935)	1682 (5778)	1320 (4405)	616 (1584)	351 (1024)	80 (174)	1580 (2756)
Total insured liability ($ 1,000)	185 (484)	137 (429)	162 (406)	364 (1585)	487 (2116)	273 (1376)	67 (280)	341 (894)	4694 (10393)
Total premium ($ 1,000)	27.03 (84.08)	25.34 (74.76)	26.66 (75.01)	63.63 (295.93)	50.08 (215.30)	29.65 (93.21)	9.76 (35.58)	44.85 (166.02)	190.85 (461.54)
Total subsidy ($ 1,000)	16.46 (53.35)	16.60 (52.84)	16.37 (48.94)	41.24 (198.45)	31.00 (145.33)	17.94 (57.93)	6.02 (21.47)	27.04 (97.96)	109.74 (261.02)
Total indemnity ($ 1,000)	22.80 (97.59)	24.85 (102.58)	29.53 (115.61)	51.30 (250.20)	42.57 (314.93)	28.22 (123.04)	8.45 (62.93)	49.70 (225.94)	188.13 (928.37)
Premium per dollar of liability	0.15 (0.09)	0.21 (0.11)	0.17 (0.08)	0.18 (0.08)	0.14 (0.11)	0.15 (0.10)	0.16 (0.10)	0.14 (0.13)	0.04 (0.03)
Subsidy per dollar of premium	0.61 (0.07)	0.62 (0.07)	0.60 (0.09)	0.61 (0.10)	0.61 (0.10)	0.60 (0.08)	0.62 (0.05)	0.61 (0.05)	0.60 (0.06)
Producer paid premium rate	0.06 (0.04)	0.08 (0.05)	0.07 (0.04)	0.07 (0.04)	0.05 (0.05)	0.06 (0.04)	0.06 (0.04)	0.05 (0.05)	0.02 (0.01)
Actuarial data master outcomes									
Reference rate	0.04 (0.01)	0.04 (0.01)	0.03 (0.01)	0.04 (0.02)	0.03 (0.02)	0.03 (0.02)	0.02 (0.01)	0.02 (0.02)	0.01 (0.01)
Fixed rate	0.13 (0.07)	0.15 (0.08)	0.13 (0.07)	0.12 (0.06)	0.10 (0.09)	0.12 (0.08)	0.13 (0.08)	0.13 (0.11)	0.04 (0.02)
Rating exponent	-1.33 (0.67)	-1.54 (0.57)	-0.66 (0.64)	-1.39 (0.61)	-1.43 (0.53)	-1.09 (0.71)	-0.77 (0.83)	-0.09 (0.27)	-1.03 (0.65)
Coverage level differential factor-50%	0.69 (0.12)	0.70 (0.11)	0.71 (0.11)	0.71 (0.10)	0.67 (0.11)	0.68 (0.12)	0.64 (0.13)	0.61 (0.17)	0.50 (0.11)
Coverage level differential factor-55%	0.80 (0.12)	0.78 (0.13)	0.84 (0.07)	0.80 (0.11)	0.76 (0.12)	0.81 (0.11)	0.80 (0.09)	0.80 (0.12)	0.68 (0.07)
Coverage level differential factor-60%	0.87 (0.12)	0.86 (0.14)	0.92 (0.05)	0.88 (0.11)	0.85 (0.11)	0.88 (0.11)	0.89 (0.09)	0.89 (0.07)	0.81 (0.07)
Coverage level differential factor-65%	0.95 (0.12)	0.94 (0.13)	0.99 (0.04)	0.96 (0.11)	0.95 (0.12)	0.97 (0.10)	0.98 (0.09)	1.00 (0.02)	0.98 (0.08)
Coverage level differential factor-70%	1.06 (0.12)	1.03 (0.11)	1.08 (0.05)	1.06 (0.09)	1.08 (0.12)	1.07 (0.10)	1.08 (0.09)	1.12 (0.08)	1.19 (0.10)
Coverage level differential factor-75%	1.20 (0.16)	1.14 (0.08)	1.17 (0.08)	1.17 (0.08)	1.22 (0.14)	1.20 (0.14)	1.21 (0.12)	1.25 (0.16)	1.45 (0.13)
Coverage level differential factor-80%	1.34 (0.22)	1.26 (0.07)	1.27 (0.11)	1.28 (0.09)	1.39 (0.20)	1.33 (0.21)	1.30 (0.16)	1.37 (0.24)	1.71 (0.16)
Coverage level differential factor-85%	1.51 (0.32)	1.38 (0.10)	1.38 (0.15)	1.40 (0.12)	1.57 (0.28)	1.48 (0.30)	1.41 (0.24)	1.48 (0.34)	2.00 (0.21)
Basic unit differential factor	1.03 (0.02)	1.03 (0.02)	1.05 (0.02)	1.06 (0.03)	1.03 (0.03)	1.04 (0.02)	1.03 (0.02)	1.04 (0.02)	1.03 (0.02)
Enterprise unit differential factor	1.02 (0.01)	1.02 (0.01)	1.03 (0.01)	1.03 (0.01)	1.01 (0.04)	1.02 (0.01)	1.01 (0.01)	1.00 (0.01)	1.00 (0.01)
Number of insurance pools	16,311	15,723	10,677	6,699	599,534	31,450	14,312	2,512	802
Number of observations	56,998	55,349	39,338	22,733	3,587,393	119,107	56,199	14,034	7,020

The data was constructed by the authors using primary data from (1) Risk Management Agency's summary of business and actuarial data master files that contain insurance metrics aggregated by county, crop, crop type, production practice, insurance plan, coverage level, and insurance unit.

Figure S1: Graphical Representation of the Premium Rating Parameter Updating Sequence in the United States Federal Crop Insurance Program

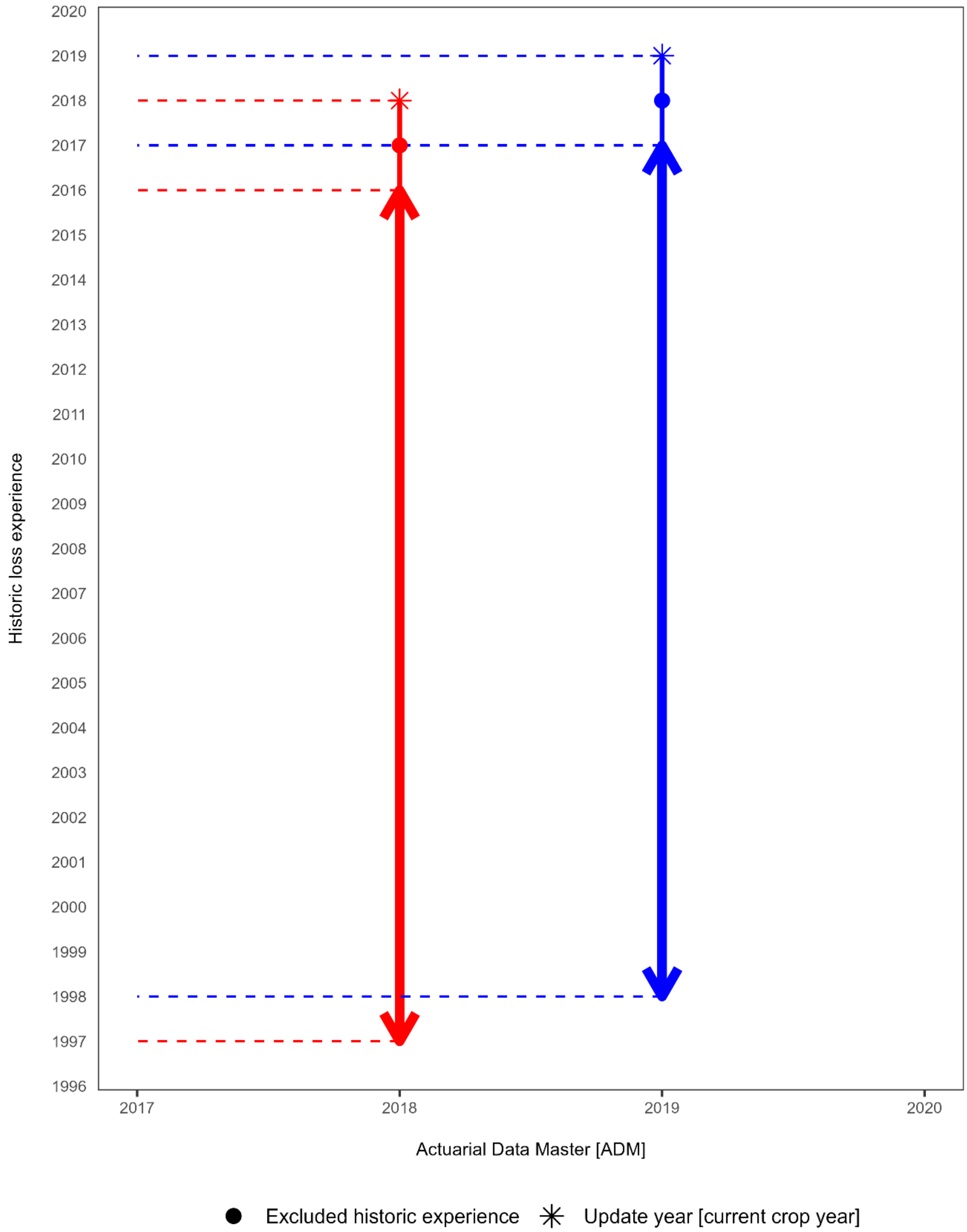


Figure S2: The responsiveness of insured acres to rating parameter updates in the US Federal Crop insurance Program

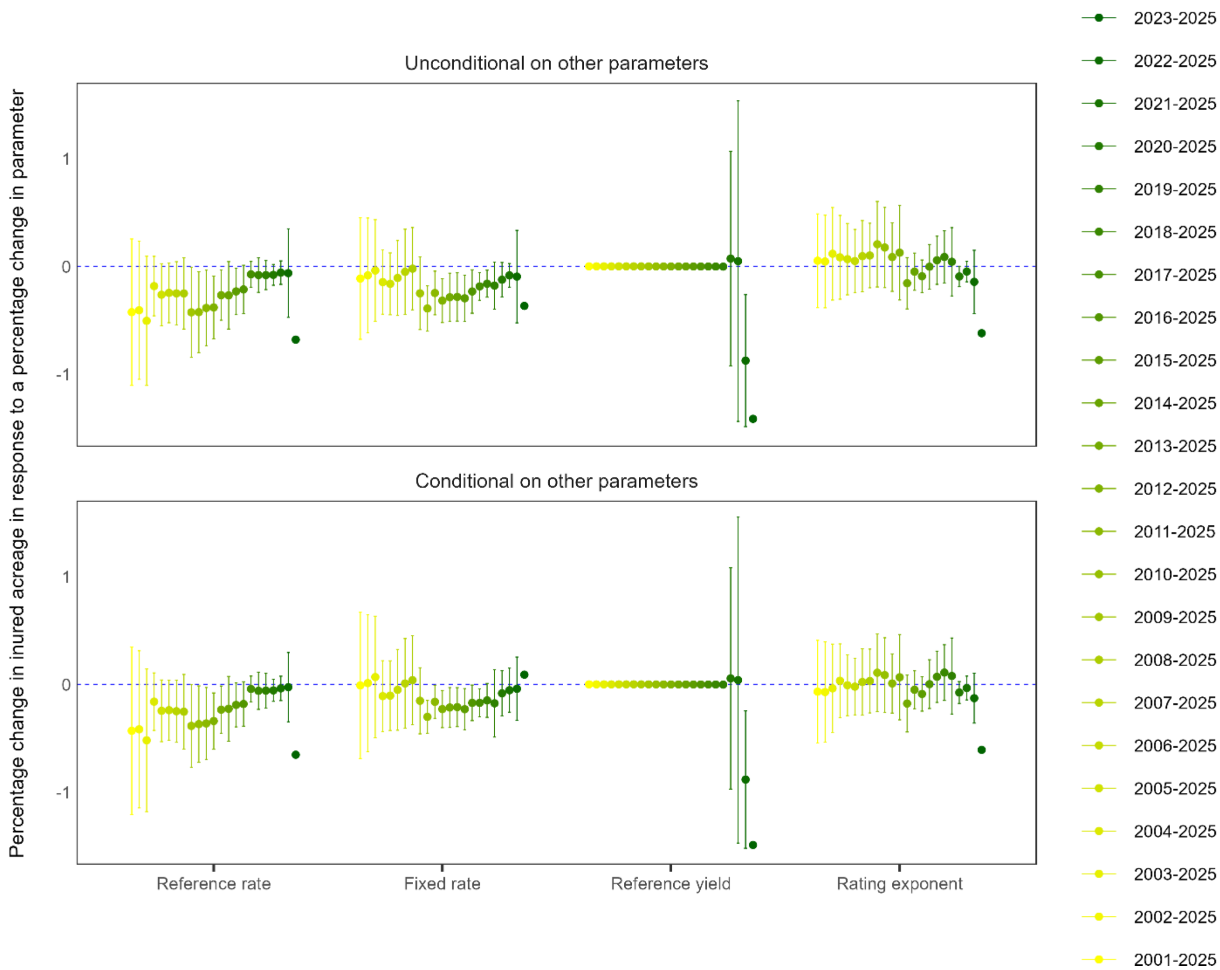


Figure S3: Estimated elasticities

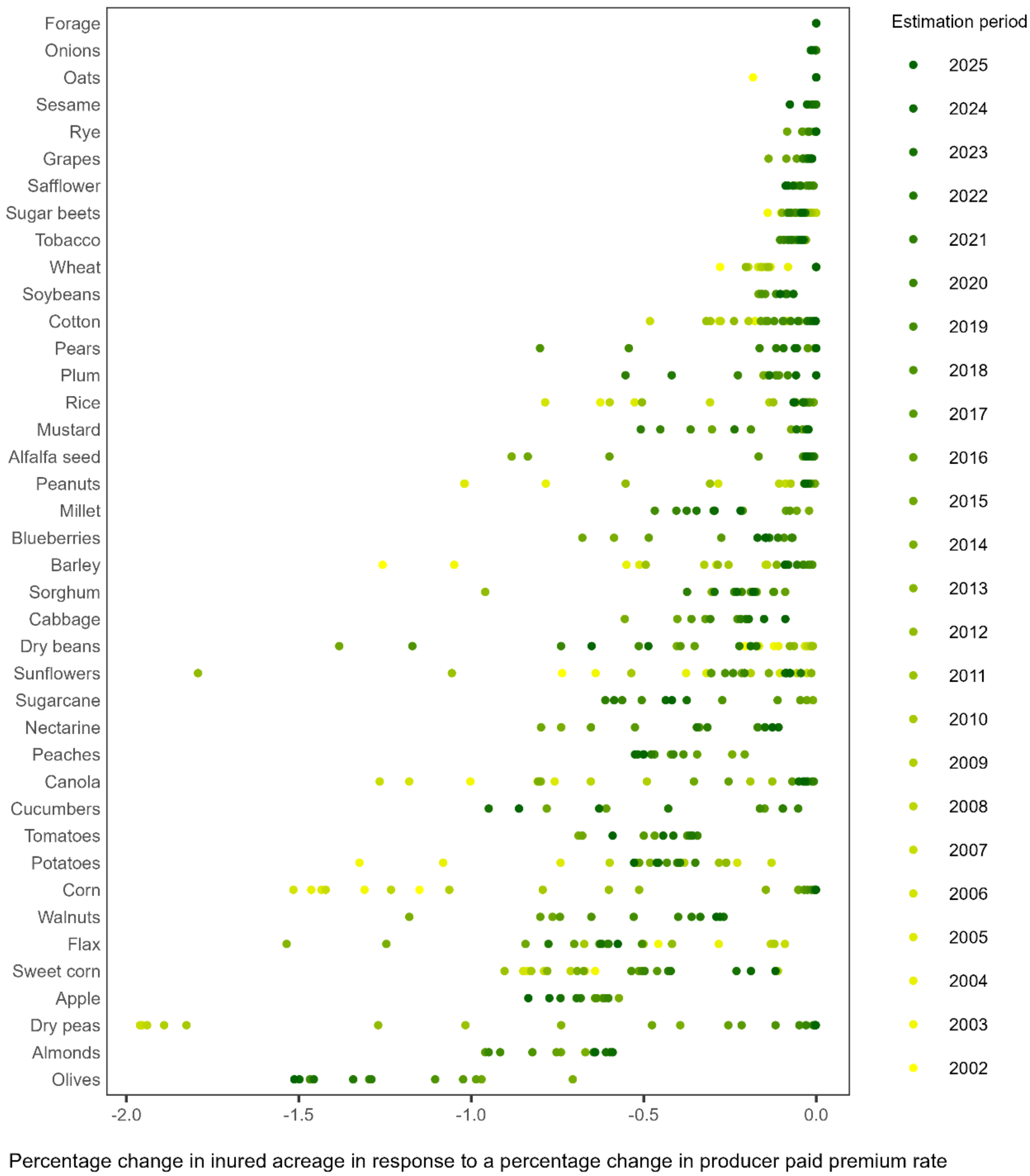
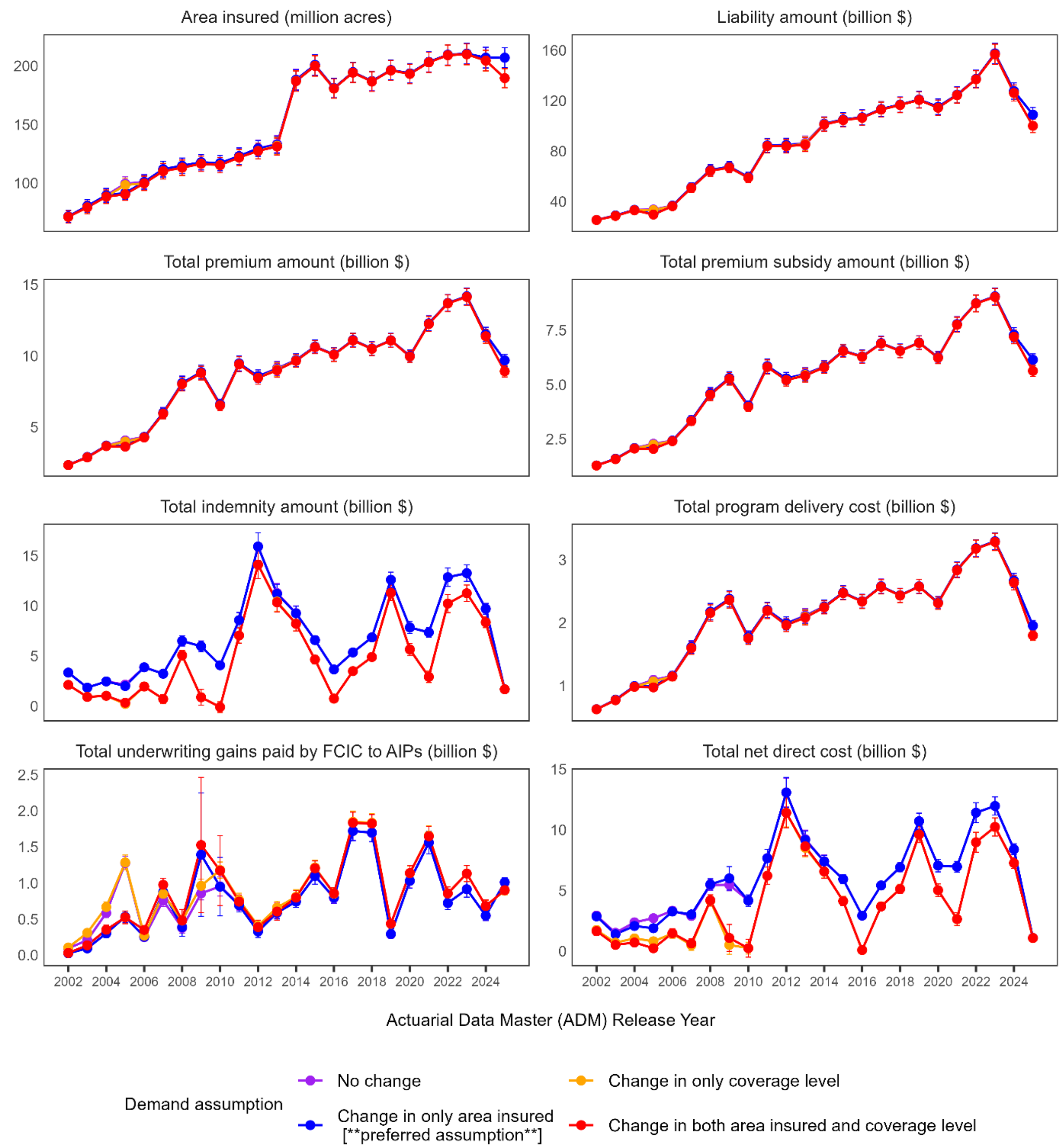


Figure S4: Fiscal impacts of actuarial updates in the United States Federal Crop Insurance Program (2002-24) – Adjusted Demand



About the Agricultural Risk Policy Center

The Agricultural Risk Policy Center at North Dakota State University conducts independent, evidence-based economic research to inform agricultural policy and strengthen the farm safety net. Our work focuses on evaluating risk management tools such as crop insurance and disaster assistance, analyzing market disruptions, and providing timely insights that support agricultural producers, policymakers, and industry leaders.

Strengthening the U.S. Farm Safety Net with Evidence-based Policy Insights.

Contact Us

arpc@ndsu.edu

www.ndsu.edu/agriculture/arpc

Richard H. Barry Hall 400, Fargo, ND

https://www.linkedin.com/company/ndsu-agricultural-risk-policy-center

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