A Fractional Multinomial Logit Estimation of Price Elasticities of Crop Insurance Demand

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Abstract

We estimate demand elasticities for crop insurance coverage options using a county-level fractional multinomial logit model for U.S. corn (2001–2023). The model accounts for bounded expenditure shares, cross-equation restrictions, substitution across coverage levels and unit structures, and dynamic adjustments—thereby allowing nuanced modeling of farmers' responses to subsidy changes. Elasticity values with respect to buyup subsidy rates rise with broader coverage option sets, and total implied liability can be price-elastic when all buyup farmer-paid premium rates move together. Policy applications—CBO's proposed subsidy reduction and the 2025 Reconciliation Bill—show substantial long-run shifts in portfolio composition, underscoring the need to incorporate farmers' behavioral responses into policy scoring.

Keywords: dynamic scoring, panel data, demand system, recency effects, budget heuristics

1. Introduction

Evaluations of policy proposals to reduce federal crop insurance program expenditures often hinge on assumed demand elasticities. The Government Accountability Office (GAO, 2014, p. 22; GAO, 2023a) has applied static scoring, assuming no behavioral response from farmers in participation or coverage levels. While declaring the view that farmer response is likely small, GAO makes no adjustments for it. In contrast, the Congressional Budget Office (CBO, 2017,

2022) has used dynamic scoring, incorporating some responsiveness but adopting relatively low elasticity estimates based on its literature review.[1]

These elasticity assumptions are central to both agencies' conclusions: a modest behavioral response implies substantial potential government savings from reduced premium subsidies.[2] However, this premise appears inconsistent with observed patterns of increased participation—both extensive and intensive—in response to past legislative changes in subsidy structures (see Footnote 4 and Collins, 2013). Accurate policy evaluation, therefore, depends on precise measurement and understanding of farmers' responsiveness to subsidy changes. If farmers' downward response in coverage levels or participation is underestimated, crop insurance's role in deterring ad hoc disaster assistance may be weakened, and the projected savings in GAO (2014, 2023) and CBO (2017, 2022) may fail to materialize (Innes, 2003; Bulut, 2017).

To address this gap, we estimate crop insurance demand elasticities by using a fractional multinomial logit model. Our method accommodates the bounded nature of expenditure shares for coverage options at the county level and extends the fractional logit model of Papke and

[1] In the December 2017 report, the CBO considered a scenario in which the average subsidy rate is reduced from 62% to 47%, that is a drop of 15 percentage points (henceforth, ppts). As noted on p. 21 of the report (footnote 34 therein), the coverage level impacts are downwards: 5 ppts at 85%, 10 ppts at 80%, 15 ppts at 75%, and 10 ppts at 70%. The elasticity is obtained as the ratio of the % change in coverage demand to the % change in farmer-paid premium rate. In the numerator, we take the average coverage level as 70% (which is a bit higher than the calculated figures for 2022 in the data section) and the average drop in coverage as 10 ppts, which translates as 14.3% drop in the coverage level. In the denominator, a 15 ppts drop in the average subsidy rate results in a nearly 40% increase in the average farmer-paid premium rate. Combining the two, the elasticity values used by the CBO appears to be 0.36 in absolute value.

[2] In the December 2017 report, the CBO estimated $8.1 Billion savings over the period 2018-2027 as a result of a 15 ppts drop in the average subsidy rate, which translates as $810 million per year savings. In addition, the GAO (2014) notes "the federal government would have potentially saved more than $400 million in 2012 by reducing premium subsidies by 5 ppts, and the savings would have been nearly $2 billion by reducing these subsidies by 20 ppts."

Wooldridge (1996) to a multinomial setting (see Buis, 2020; Koch, 2010). This framework satisfies the adding-up constraint from demand theory, and our farmer-paid premium rate variables are homogeneous of degree zero. We are the first to develop and incorporate a quasi-symmetry condition consistent with demand theory as cross-equation restrictions into the fractional multinomial logit framework.

Previous elasticity studies often rely on aggregate demand measures such as the average coverage level, overlooking key contractual flexibilities such as unit structure and coverage level combinations. To better capture behavioral response, we focus on the 2009 policy change affecting enterprise units—a natural policy experiment overlooked in most literature (notable exceptions include Bulut, 2020; Klosin and Solomon, 2024). Enabled by the 2008 Farm Bill, the USDA's Risk Management Agency (RMA) raised subsidy rates on enterprise units to equalize subsidy dollars across unit types. Since enterprise units typically carry lower premiums, this resulted in substantially higher subsidy rates for them (see Supplementary Appendix 1). The policy shift produced significant demand responses across unit structures (Figures 1a and 1b). Although enterprise units have been available since 1999, they were not widely adopted initially due to their higher aggregation level. The rise in adoption appears to be driven by subsidy increases.

A further challenge in estimating elasticities is the potential endogeneity of farmer-paid premium rates or average subsidy rates. We address this by constructing instruments based on RMA's premium rating parameters, including base rate, coverage rate differentials, unit residual factors, and unit structure discount factors. These instruments draw on and expand the approaches taken in Tsiboe and Turner (2023) and Woodard and Yi (2020). Because rating parameters are determined with a lag and are unaffected by contemporaneous coverage

decisions, they serve as valid instruments. Moreover, they vary across time and space, and are not directly influenced by other farm or disaster aid programs.[3] Our dataset includes the full set of rating parameters for the 2001–2023 period.

This article contributes to the literature in several key ways. We adopt an expenditure share framework akin to the Almost Ideal Demand System to estimate elasticities, using coverage option–level data aggregated by unit structure and coverage level—a novel approach in the crop insurance demand literature. The number of coverage options considered—ranging from 4 to 25—depends on the aggregation of individual plan buyup coverage levels, and the framework also incorporates traditional area coverage, supplemental area or index-based plans, and CAT coverage. This structure allows us to examine substitution patterns both within and across these categories. We derive elasticity formulas for total implied liability in response to buyup subsidy rate changes and estimate them using county-level coverage expenditure share data for corn from 2001 to 2023. The econometric model incorporates an autoregressive component to capture the dynamic evolution of expenditure shares over time. Our results show that elasticity values with respect to buyup subsidy rates rise as substitution possibilities expand, with higher values obtained when a greater number of coverage options is considered (Figure 2a).

To demonstrate policy relevance, we apply our elasticity estimates to two policy scenarios. The first evaluates the Congressional Budget Office's proposal for a 15-percentage-point reduction in the average buyup subsidy rate, a broad reform intended to reduce federal crop

[3] These programs are administered by the Farm Service Agency (FSA) and include the Average Crop Revenue Election (ACRE) program, Supplemental Revenue Assistance Program (SURE), the Wildfire and Hurricane Indemnity Program Plus (WHIP+), and the Emergency Relief Program (ERP). More information can be found at the FSA's website: https://www.fsa.usda.gov/ .

insurance expenditures. The second examines the 2025 Reconciliation Bill's option-specific subsidy rate changes, which are more targeted in design. These scenarios differ in both the scale and targeting of subsidy adjustments, allowing us to compare their impacts on total implied liability as well as their short- and long-run effects on portfolio composition.

The remainder of this article proceeds as follows. The next section provides background on relevant policy changes and highlights key findings from the literature. We then present analytical elasticity derivations for additive subsidy rate changes at buyup levels, followed by the econometric estimation of expenditure share impacts and presentation of elasticity results. The two policy applications are then analyzed. We conclude with a summary of findings and directions for future research.

2. Policy Background and Literature Review

The origins of the federal multiple peril crop insurance (MPCI) program in the U.S. go back to the 1934-36 drought. However, only in the late 1990s did the program gain prominence as a means of securing farm financial stability (Collins, 2013). It took several Acts for Congress to restructure the program and increase premium subsidies—all with the intent of replacing costly disaster aid payments.[4] In the end, the 2014 Farm Bill marked, and the 2018 Farm Bill reaffirmed, the shift in the farm policy towards risk management and cemented crop insurance at the farm safety net's center. All the while, crop insurance premium subsidies—which are projected by the CBO (2023) to constitute about 82% of all government support to this program over the next decade—have been questioned. Policy perspectives and budget issues have

[4] The Federal Crop Insurance Reform Act of 1994 (1994 Act) increased subsidy rates primarily at the lower insurance coverage levels, while the Agricultural Risk Protection Act of 2000 (ARPA) increased rates more at the higher coverage levels. Premium subsidy rates were further increased for enterprise units in 2009 following the authorization under the Food, Conservation, and Energy Act of 2008.

motivated many calls for program expenditure reductions (Goodwin and Smith, 2013; Glauber, 2013; Bekkerman, Belasco and Smith, 2019; Belasco, 2022).

As noted in the CBO review, a large body of works have found demand elasticity values lower than one, i.e., to be inelastic. These studies typically regressed some measure of crop insurance purchases (coverage levels or liability per acre) on the farmer-paid premium rate. The CBO report points to a methodological issue previously raised in Woodard (2016). Woodard noted—and Tsiboe and Turner (2023) further explored—that prior studies have fallen short of properly accounting for the endogeneity issue arising from the simultaneous choice of insurance quantity and the attendant price. While a few studies have suggested near unitary or elastic crop insurance demand, it appears that these studies did not carry the same weight as others in the CBO review. For example, the CBO merely cites Richards (2000, p.183) who finds an elastic response in a specialty crops context. O'Donoghue and Tulman (2016, pp. 21-22) find elasticity values near one for corn and above one for soybeans, yet this study was not cited in the CBO review. Finally, the CBO apparently opted for the result when coverage levels were unadjusted in Woodard (2016), which shows -0.33 and hence suggests inelastic demand (footnote 1).[5]

Heerman et al. (2016) is the only other study to also take a shares approach in estimating elasticities; however, they only considered market shares within insured acres and buyup coverage. In their simulations, the elasticity in terms of subsidy expenditure turns out to be inelastic. In one of the scenarios, for instance, a 5% (proportional) cut in subsidy rates for all buyup coverage levels reduces the subsidy expenditures for corn by $80 million in 2009, a less

[5] Woodard (2016), which has the same results as in Woodard and Yi (2018, see the third panel, p. 20), reports an elasticity coefficient of near 1 once buyup coverage levels (the dependent variable) were adjusted to reflect their differences over catastrophic coverage. Nevertheless, in this case, the interpretation of the elasticity value depends on how the adjustment was made and the text is unclear on that point.

than 4% reduction as the subsidy expenditures stood at $2.03 billion for the same crop in that year.

3. Elasticity Formulations

We derive formulations for the average elasticity of total implied liability (quantity) with respect to an additive change in subsidy rates for buyup coverage options, both in the short term and long term.

Let an insurance coverage option be indexed by $i = 1, 2, ..., I$. The farmer-paid premium rate associated with the coverage option i is denoted by r_i, and the vector of all such rates is represented by r. The quantities and budget shares for the i^{th} coverage option are q_i and w_i, respectively. The total insurance quantity and the total expenditure on all coverage options in a county are Q and X, respectively.

Insurance quantities (implied liabilities) can be solved from budget shares as

$$q_i = \frac{w_i X}{r_i}. \tag{1}$$

The total implied liability is

$$Q = \sum_{i \in I} q_i , \tag{2}$$

where $q_i \equiv q_i(r, X)$ conditional Marshallian (uncompensated) demand functions.

Total differentiation of equation (2) yields

$$d\ln(Q) = \sum_i \sum_j \varepsilon_{ij} \frac{dr_j}{r_j} \frac{q_i}{Q} + \sum_i \varepsilon_i \frac{dX}{X} \frac{q_i}{Q}, \tag{3}$$

where $\varepsilon_{ij} = \frac{\partial q_i}{\partial r_j}\frac{r_j}{q_i}$ are the own and cross-price elasticities and $\varepsilon_i = \frac{dq_i}{dX}\frac{X}{q_i}$ are the expenditure elasticities. Since we work with conditional demands, $dX = 0$ and the last term drops in equation (3).

The farmer-paid premium rate for option i is

$$r_i = \left(1 - (s_i + \theta)\right)\pi_i, \tag{4}$$

where θ is the additive subsidy rate change, while π_i is the respective full premium rate. Differentiating r_i with respect to θ and then setting $\theta = 0$ yields

$$\frac{dr_i}{d\theta}\Big/ r_i = -\frac{1}{(1 - s_i)}. \tag{5}$$

Substituting $\frac{dr_i}{r_i} = -\frac{d\theta}{(1 - s_i)}$ in equation (3) results in

$$\frac{d\ln(Q)}{d\theta} = \sum_i \sum_j \varepsilon_{ij} \frac{-1}{(1 - s_j)}\frac{q_i}{Q}. \tag{6}$$

This expression gives the percent change in total implied liability for a percentage point additive change in subsidy rate.

To estimate ε_{ij} values, denote the marginal effect of $\ln(r_j)$ in equation i by γ_{ij} and the marginal effect of real expenditures $\ln(\frac{X}{\Gamma})$ by β_i. Note that $\Gamma = \sum_{j=1}^{J} w_j \ln(r_j)$ is the Stone index, which is unit-free here as it is composed of farmer-paid premium rates.

Since $\ln(\frac{X}{\Gamma}) = \ln(X) - \ln(\Gamma) = \ln(X) - \sum_{j=1}^{J} w_j \ln(r_j)$ holds and the parameter β_i applies to the entire term, it follows that

$$\frac{\partial w_i}{\partial \ln r_j} = \gamma_{ij} - \beta_i w_j \,. \tag{7}$$

From the definition of the expenditure share, consistent with equation (1), it also follows

$$\frac{\partial w_i}{\partial \ln r_j} = w_i \varepsilon_{ij} \text{ when } i \neq j \text{ and } \frac{\partial w_i}{\partial \ln r_j} = w_i(1+\varepsilon_{ij}) \text{ when } i = j \,. \tag{8}$$

Combining equations (7) and (8), one arrives at

$$\varepsilon_{ij} = \frac{\gamma_{ij}}{w_i} - \beta_i \frac{w_j}{w_i} - \delta_{ij} \;\; , \tag{9}$$

where δ_{ij} is the Kronecker delta, which takes the value of 1 when $i = j$ and 0 otherwise.

All derivations so far apply to a given county k and in a given year t. Denote the number of observations across counties and over time by $kt = 1,...,N$. Looking at the average effects, first define the price elasticity that is weighted by the implied total liability as

$$\overline{\varepsilon}_{ij,h_i} = \sum_{kt=1}^{N} \varepsilon_{ij,kt} h_{i,kt} \Big/ N = \sum_{kt=1}^{N} \left(\frac{\gamma_{ij,kt}}{w_{i,kt}} - \beta_{i,kt} \frac{w_{j,kt}}{w_{i,kt}} - \delta_{ij} \right) \frac{q_{i,kt}}{Q_{kt}} \Big/ N \,, \tag{10}$$

where $\frac{q_{i,kt}}{Q_{kt}}$ is the implied liability weight of the coverage option i. Using the preceding elasticity, one can write the average total implied liability elasticity as

$$\sum_{kt=1}^{N} \frac{d \ln(Q_{kt})}{d\theta} \Big/ N = \sum_i \sum_j \overline{\varepsilon}_{ij,h_i} \frac{-1}{(1-s_j)} \,. \tag{11}$$

The preceding expression gives the average percent change in total implied liability for a percentage point additive change in subsidy rate.

The foregoing framework can be applied to scenarios where only a subset of the coverage options is considered for an additive subsidy rate change. For example, if only the coverage option j^* is subject to such a subsidy rate change, then the elasticity formula can be modified as

$$\sum_{kt=1}^{N} \frac{d \ln(Q_{kt})}{d\theta} \Big/ N = \sum_{i} \bar{\varepsilon}_{ij,h_i} \frac{-1}{(1-s_{j^*})}, \tag{12}$$

where the farmer-paid premium rate changes arising from subsidy rate changes (see equation (5)) are reset to zero for all $j \neq j^*$ in equation (11).

4. Data

The primary data source is the Risk Management Agency's (RMA) crop insurance Summary of Business database, reported by unit structure and coverage level at the county level. For corn, the sample period spans 2001–2023.[6] The final dataset forms an unbalanced panel of 1,688 counties, yielding 22,432 observations for each expenditure share equation.

Control variables are drawn from multiple sources. Base insurance prices and volatility factors are calculated and announced annually by RMA, based on futures prices and implied volatility measures obtained from Barchart.com. The fertilizer price index, which includes lime and soil conditioners, is sourced from USDA–NASS Quick Stats on both a monthly and annual basis. Palmer's Z-Index values—measuring deviations from monthly normal moisture conditions—are obtained from NOAA's National Centers for Environmental Information. Originally published at the climate-division level, these monthly values are converted to the county level and used to construct the *Dryness* and *Wetness* variables (described in the next section).

We now turn to the econometric model used to estimate the effects of explanatory variables on expenditure shares.

[6] Since one observation is lost to the lagged dependent variable in the estimations, the effective sample size begins in 2001. We focus on the post-ARPA period in our analysis and consider 2000 as a transitional year. The ARPA (2000) provided a permanent increase in subsidies and had passed about the mid-year. The legislation was separate from the temporary economic loss assistance that had started in 1999 (Chite, 2000).

5. Econometric Modeling

As specified in Koch (2010, p. 5) and Buis (2020, p.16), our objective is to estimate the conditional mean for each expenditure share

$$E\left[w_{jit} \middle| x_i \right] = \mu_j(x_{it}\mathrm{B}), \tag{13}$$

where $j = 1,...,J$ indexes all coverage options, $i = 1,...,I$ indexes counties, $t = 1,...,T$ indexes years, $N = IT$ is the total number of observations, x_{it} is the set of all explanatory variables considered (with the dimensionality of p), $\mathrm{B} = \left\{ \beta_j \right\}_{j=1}^{J}$ is the set of all parameters across all expenditure shares, and μ_{jit} is the index function in the form of the inverse multinomial logit link function:

$$\mu_{jit} = \begin{cases} \dfrac{e^{x_{it}\beta_j}}{1 + \sum_{k=1}^{J-1} e^{x_{it}\beta_k}} & if \quad j < J \\ \\ \dfrac{1}{1 + \sum_{k=1}^{J-1} e^{x_{it}\beta_k}} & if \quad j = J. \end{cases} \tag{14}$$

Notice that $\beta_J = \left[0\right]_{p\times 1}$ by the way of normalization and $\sum_{j=1}^{J} \mu_{jit} = 1$.

Looking at the symmetry property, one obtains marginal effects

$$\frac{\partial \mu_{jit}}{\partial \ln(r_{lit})} = \mu_{jit}\left(\beta_{jl} - \sum_{k=1}^{J-1} \mu_{kit}\beta_{kl} \right), \tag{15}$$

$$\frac{\partial \mu_{lit}}{\partial \ln(r_{jit})} = \mu_{lit}\left(\beta_{lj} - \sum_{k=1}^{J-1} \mu_{kit}\beta_{kj} \right).$$

Now, denote the number of observations across counties and over time by $it = 1,...,N$ and define the symmetry property in terms of the average marginal effects as

$$\sum_{it=1}^{N} \frac{\partial \mu_{jit}}{\partial \ln r_l} \Big/ N = \sum_{it=1}^{N} \frac{\partial \mu_{lit}}{\partial \ln r_j} \Big/ N \ , \tag{16}$$

which in turn reduces to

$$\sum_{it=1}^{N} \mu_{jit} \left(\beta_{jl} - \sum_{k=1}^{J-1} \mu_{kit} \beta_{kl} \right) \Big/ N = \sum_{it=1}^{N} \mu_{lit} \left(\beta_{lj} - \sum_{k=1}^{J-1} \mu_{kit} \beta_{kj} \right) \Big/ N \ . \tag{17}$$

Notice that $\sum_{k=1}^{J-1} \mu_{kit} \beta_{kl}$ and $\sum_{k=1}^{J-1} \mu_{kit} \beta_{kj}$ inside the parentheses represent the weighted sums of the parameters associated with $\ln(r_{jit})$ and $\ln(r_{lit})$ for coverage options j and l for a given county i in year t. The following will generally hold

$$\sum_{k=1}^{J-1} \mu_{kit} \beta_{kj} \neq \sum_{k=1}^{J-1} \mu_{kit} \beta_{kl} \ . \tag{18}$$

This is because the preceding summations refer to separate explanatory variables, while equation (14) in Koch (p.8)—which shows marginal effects vanish—refers to a given explanatory variable indexed by l and results in $\sum_{j=1}^{J-1} \mu_{jit} \beta_{jl} = \sum_{k=1}^{J-1} \mu_{kit} \beta_{kl}$ where only the indices j and k that track the parameters β_{jl} and β_{kl} across shares differ. Rearranging the terms in equation (17) yields

$$\bar{\mu}_j \beta_{jl} - \bar{\mu}_l \beta_{lj} = \sum_{k=1}^{J-1} \mu_{kit} (\bar{\mu}_j \beta_{kl} - \bar{\mu}_l \beta_{kj}) , \tag{19}$$

where $\bar{\mu}_j = \sum_{it=1}^{N} \mu_{jit} \Big/ N$ and $\bar{\mu}_l = \sum_{it=1}^{N} \mu_{lit} \Big/ N$. Since the combination of shares μ_{kit} for $k = 1 ... J-1$ will vary across counties and over time, while the terms $(\bar{\mu}_j \beta_{jl} - \bar{\mu}_l \beta_{lj})$ and $(\bar{\mu}_j \beta_{kl} - \bar{\mu}_j \beta_{kl})$ for $k = 1 ... J-1$ remains the same, the condition given in equation (19) will unlikely to hold whenever the parameters β_{jl}, β_{lj}, β_{kl}, and β_{kj} non-zero. As an alternative, further summing

both sides of equation (19) over the sample observations $it = 1,...,N$ and swapping the order of summations on the right side of the equation results in

$$N(\bar{\mu}_j \beta_{jl} - \bar{\mu}_l \beta_{lj}) = \sum_{k=1}^{J-1} \sum_{it=1}^{N} \mu_{kit} (\bar{\mu}_j \beta_{kl} - \bar{\mu}_l \beta_{kj}),$$

which in turn can be reexpressed as

$$\bar{\mu}_j \beta_{jl} - \bar{\mu}_l \beta_{lj} = \sum_{k=1}^{J-1} \bar{\mu}_k (\bar{\mu}_j \beta_{kl} - \bar{\mu}_l \beta_{kj}), \tag{20}$$

where $\bar{\mu}_k = \sum_{it=1}^{N} \mu_{kit} \Big/ N$.

For a 25 unit structure and coverage level options, the most considered here, equation (20) implies 300 cross-equation restrictions, which are coded in Stata software and passed into its *fmlogit* routine during the estimations.

The 25 unit structure and coverage level options include optional units with coverage levels from 50% to 85% (8 options), basic units with coverage levels from 50% to 85% (8 options), and enterprise units with a low coverage category (50%, 55%, and 60% combined) plus higher coverage levels from 65% to 85% (6 options). Additional categories are non-supplemental area plans—standalone area-trigger products such as GRP, GRIP, and ARPI—and supplemental area or index-based plans introduced after the 2014 Farm Bill, notably SCO (2014), HIP-WI (2020), and ECO (2021), all defined on the same acre as the underlying base policy. Catastrophic (CAT) coverage is also included as a distinct option within the 25-coverage-option specification.

The number of coverage options ranges from 4 to 25, depending on how individual plan buyup coverage levels are disaggregated, while the other three categories—non-supplemental area, supplemental area/index, and CAT—remain fixed. For example, 4 options treat all individual buyup coverage as a single category, whereas 6 options split it into optional unit, basic

unit, and enterprise unit categories. Further dividing unit-based categories into low–medium (50%–70%) and high (75%–85%) coverage yields 9 options, including optional unit low–medium, optional unit high, basic unit low–medium, basic unit high, enterprise unit low–medium, and enterprise unit high. This process similarly produces 12, 15, and 21-option specifications: the 12-option case splits low–medium into separate low (50%–60%) and medium (65%–70%) categories for all units; the 15-option case separates medium into distinct 65% and 70% coverage levels; and the 21-option case further splits high into 75%, 80%, and 85% coverage levels.

Recall that the 25-option case includes a low (50%–60%) category for enterprise units. While this could be further split into distinct coverage levels to create a 27-option case, we refrain from doing so for the following reason. Estimating elasticities as in equations (10) requires recovering marginal effects after estimating expenditure share equations with Stata's *fmlogit* routine, which reports and stores only average marginal effects. Using our own programming, we validated these averages with high precision up to the 25-option case. However, in the 27-option case, minor discrepancies emerged between the average marginal effects in some equations and variables, so we limit our reporting to the 25-option case.

The explanatory variables x_{it} from equation (13) include both lagged and other time-varying and fixed factors. One-period lagged expenditure shares are included to capture economic dynamics and persistence in coverage choices. Given the 23-year time span, only a single lag is used, with values aggregated consistently with the dependent variables.

From a demand theory perspective, the primary economic variables of interest are prices and expenditures. In this setting, these are represented by farmer-paid average premium rates for all coverage options—constructed to match the aggregation scheme—and total insurance

expenditure. Both variables are potentially endogenous because they depend on the distribution of expenditure shares the model seeks to explain, creating a risk of biased parameter estimates. To address this, both are instrumented using a two-stage least squares procedure.

For farmer-paid average premium rates, the instruments are derived from RMA's yield-plan rate parameters—reference rate, rate differential factor, unit residual factor, and unit structure discount factor. Because most premiums are for revenue plans and no closed-form transformation from yield-plan to revenue-plan rates exists, changes in the base insurance price and volatility factor are included among the exogenous regressors in the first-stage equations to improve projection accuracy.

For total insurance expenditure, the instrument is the county-level value of crop production, calculated as the product of the base insurance price, reference yield, and planted acres (adjusted for prevented planting). Total insurance expenditure, normalized by its sample mean, is projected onto this instrument and the other exogenous variables. The fitted values are then divided by the Stone index of instrumented farmer-paid average premium rates to produce a real-expenditure measure. Weather and productivity controls include county-level means and standard deviations of the National Commodity Crop Productivity Index (NCCPI), rolling 20-year averages of growing degree days, stress degree days, and precipitation. To capture the influence of extreme weather on coverage and unit structure choices (Che, Feng, and Hennessy 2020), counts of extreme dryness and wetness events from May through December of the prior year are included, with dryness defined as a Palmer's Z-index below –2.0 and wetness as above 2.5, following Gong, Feng, and Hennessy (2023).

Price and cost shocks are measured by year-over-year changes in the base insurance price, the volatility factor, and the January fertilizer price index (relative to the 2011 base year).

For corn, changes in base insurance prices and volatility factors together explain up to 92% of the variation in premium-per-acre changes for buyup coverage. Base insurance prices, set from futures markets, determine crop insurance guarantees, while volatility factors, based on options prices, measure price risk in revenue protection policies (Bulut and Fortenbery 2022). Both are largely market-determined, so any feedback from coverage shares to these variables is expected to be minimal. The January fertilizer price index reflects anticipated input costs before the February price discovery period; sharp increases in 2008 (preceding the enterprise unit policy change) and in 2021–2022 (post-pandemic) may have influenced coverage choices through budget-constraint effects (Bulut 2018).

Additional controls include the number of ad hoc disaster aid recipients (with aid dollars instrumented following Turner and Tsiboe 2022), farm size concentration measures from the Census (log share of farms with sales over $100,000 and log share of total sales from such farms), and the share of irrigated harvested acres. Regional fixed effects—Appalachia, Delta, Lake States, Northeast, Northern Plains, Southeast, Southern Plains, and Mountain Pacific—are included, with the Midwest as the base category.

In the 25-coverage-option specification for corn, these covariates yield 65 estimated parameters. Some variables (e.g., base insurance price, volatility factor, fertilizer price index) vary only over time, while others vary across both time and space. In essence, equation (14) reflects that, absent exogenous shocks to buyup subsidy rates, extreme weather, or changes in prices and volatility, expected market shares in the next year depend largely on current-year shares—consistent with anecdotal evidence that prior-year coverage and expenditure patterns strongly influence subsequent decisions (Bulut 2020).

6. Estimation Results

In the first-stage regressions, the value of planted acres evaluated at the county's reference yield proved to be a strong instrument for total insurance expenditures, with the model achieving an $\overline{R}^2 = 95.7\%$. Farmer-paid average premium rates for optional unit equations generally had strong instruments with $\overline{R}^2$ values ranging from 73.2% to 85.1%. For enterprise unit equations at 70% and above, instruments were also strong, with $\overline{R}^2$ values ranging from 83.2% to 89%. This was not the case for enterprise units at 65% coverage and below; nevertheless, their projections onto the full set of exogenous variables still achieved $\overline{R}^2$ values from 76.6% to 82.6%. The instruments for farmer-paid average premium rates for basic units at 55% and 65% did not work out, but projections onto all the exogenous variables yielded $\overline{R}^2$ values in the 69% to 82.8% range. The remaining farmer-paid average premium rates for basic units generally had strong instruments, with associated models generating $\overline{R}^2$ values from 72.5% to 84.3%. Farmer-paid average premium rates for area non-supplemental, area/index supplemental, and CAT coverage also had strong instruments, though the associated models generated more modest $\overline{R}^2$ values of 49.5%, 33.8%, and 31.9%, respectively. As the coverage option set becomes more disaggregated—such as in the 25-option specification—endogeneity concerns for farmer-paid average premium rates are expected to diminish, as intermixing across coverage levels becomes less pronounced. In such cases, projections onto exogenous variables should further mitigate any remaining endogeneity.

In the second-stage estimations, the fit performance of the expenditure share equations for individual buyup plans varied substantially, $\overline{R}^2$ values range from 25.4% to 85.9%. Enterprise units at 70% coverage and above generally exhibited better fit than other unit types, with the highest values at 85% coverage, where fit improved across all unit structures. At 65%

coverage, optional and basic units outperformed enterprise units, whose fit declined at this level. Among other coverage types, non-supplemental area plans, area/index supplemental plans, and CAT coverage showed solid fit performance, with pseudo-$\overline{R}^2$ values of 79.5%, 72.0%, and 65.3%, respectively.

All first-stage and second-stage regression results are available from the authors upon request. Given the large number of coverage options, detailed tables are omitted here for brevity.

7. Application

From the estimated expenditure share equations, we calculate marginal effects of farmer-paid premium rates and real expenditures. Substituting these into equation (11) yields short-run elasticity values. To illustrate their use, we present two applications.

Application 1— Uniform subsidy rate reduction as proposed by the CBO

We consider a 15-percentage-point reduction in buyup coverage subsidy rates, consistent with earlier CBO recommendations and GAO's recent proposal to limit subsidies for high-income policyholders (GAO, 2023b). Because this change applies uniformly across all buyup coverage options, the short-run elasticity formula in equation (11) is directly applicable. Figure 2a reports the average elasticity of total implied liability under alternative coverage option aggregations. In the 25-option case, the estimated elasticity is 4.587. A 15 percentage point reduction would therefore imply a 69% decline in total implied liability.

Application 2: Targeted subsidy rate adjustments under the 2025 Reconciliation Bill

The bill includes a provision (p.68) where subsidy rates for basic and optional units are increased by 5 percentage points (ppts) between 55% and 75%, and 3 ppts between 80% and 85%. Additionally, the Supplemental Coverage Option (SCO) subsidy rate is proposed to be increased from 65% to 80%, and its maximum coverage level is proposed to be increased from

86% to 90% (p.63).[7]

The increase in maximum coverage level cannot be incorporated in our current demand framework. Moreover, in our data, SCO is grouped with other area/index supplemental plans—Margin Protection (MP), Hurricane Insurance Protection–Wind Index (HIP-WI), and Enhanced Coverage Option (ECO). Thus, a subsidy rate change is applied to the entire category.

Then the short-run elasticity formula in equation (11) can be modified as

$$\Delta \ln(Q)\times 100 \cong \sum_i \sum_{j\in G_1} \overline{\varepsilon}_{ij,h_i} \frac{-1}{(1-s_j)} \Delta s_1 + \sum_i \sum_{j\in G_2} \overline{\varepsilon}_{ij,h_i} \frac{-1}{(1-s_j)} \Delta s_2 + \sum_i \overline{\varepsilon}_{ij,h_i} \frac{-1}{(1-s_{j^*})} \Delta s_3 , \qquad (21)$$

where $\Delta s_1 = 5$, $\Delta s_2 = 3$, and $\Delta s_3 = 15$ refer to the proposed subsidy rate changes (in ppts); and the summation indices $j \in G_1$ refers to a set of coverage options belonging to basic and optional units between 55% and 75%, $j \in G_2$ refers to a set of coverage options belonging to basic and optional units between 80% and 55%, and $j = j^*$ refers to the coverage option for area/index supplemental plans.

Calculations based on equation (21) indicate a 5.72% increase in implied liability—modest compared with the impact estimated for Application 1

Long-run Considerations

For both scenarios, we conduct a dynamic simulation to trace how a shock to the farmer-paid premium rate propagates over time via the model's lag structure, with other variables held at 2023 values. We implement an impulse–response analysis for each county, comparing baseline

[7] The bill, officially named "One Big Beautiful Bill Act" (OBBB Act), became law as of July 4, 2025. Legislative text can be accessed here https://www.agriculture.senate.gov/imo/media/doc/senate_ag_committee_budget_reconciliation.pdf .

projections (no policy change; Figure 3) with projections under the two policy scenarios (Figures 4 and 5). Figure 1b provides historical context, showing past expenditure-share patterns.

8. Conclusion

We derive an elasticity measure of total implied liability with respect to additive changes in buyup subsidy rates. We then evaluate this elasticity measure based on an econometric estimation of the expenditure share impacts of crop insurance coverage level options within a fractional multinomial logit model. The estimations are made for corn at the county level, covering the period 2001-2023.[8] Our approach accounts for the bounded nature of expenditure shares, imposes cross-equation restrictions consistent with economic theory, allows for substitution across a broad set of coverage levels and unit structures, and incorporates dynamic adjustments via an autoregressive structure.

Previous price elasticity studies of crop insurance demand typically considered limited categories of coverage options and often reported small elasticities. Our results indicate that elasticity values with respect to subsidy rates increase as the number of coverage options considered expands, reflecting greater substitution possibilities. When all buyup farmer-paid premium rates change in the same direction, total implied liability is found to be price-elastic (Figures 2a and 2b)—a result seldom reported in earlier literature (O'Donoghue and Tulman, 2016; Richards, 2000).

We demonstrate the policy relevance of these estimates through two applications. First, a 15 percentage-point reduction in the average buyup subsidy rate, as proposed by the CBO, would imply a short-run decline of about 69% in total implied liability for the 25-coverage option

[8] At the time of writing, the analysis was being extended to soybeans, and our approach can be applied to other major crops.

specification. Long-run projections suggest sustained reductions in enterprise unit shares across all coverage levels and in high coverage levels for optional units (Figures 3 and 4). While such changes could generate higher subsidy savings than those estimated by the CBO, they risk reversing three decades of progress in expanding participation—particularly among lower-risk producers (Yu and Perry, 2023)—and could increase reliance on ad hoc disaster aid.

Second, we examine the non-uniform, option-specific subsidy rate changes as set out in the 2025 Reconciliation Bill. In the short run, the policy produces only a modest increase in total implied liability (less than 6%). In the long run, however, projections indicate a pronounced shift in portfolio composition toward supplemental area or index-based plans, which rise to 80 percent of total share within a decade under the policy scenario, compared to 60 percent in the baseline without policy change (Figures 3 and 5).

These findings underscore the importance of evaluating both short- and long-term impacts of subsidy policy changes, and of considering portfolio composition alongside total liability, thereby contributing to more accurate policy scoring and program design. Rather than further subsidizing plans with higher basis risk, policy efforts to encourage crop insurance uptake may be better directed toward developing products that align more closely with producers' risk management needs—such as innovations in endorsements, named-peril coverage, and unit structure flexibility. Complementary investments in risk management education and outreach can also shape perceptions and adoption. Since we have found that expenditure shares for coverage options can be influenced by recent extreme weather events, premium shocks through changes in base insurance price or price risk, and production costs through changes in a fertilizer price index, further research into better understanding farmers' crop insurance decision processes is warranted.

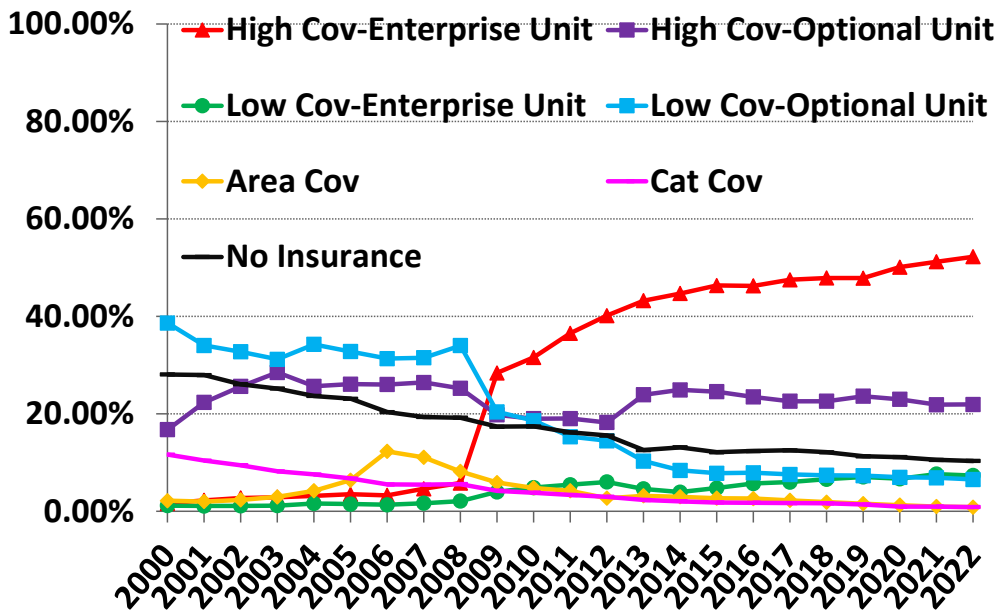


Figure 1a. Market Shares for Insurance Options by Coverage and Unit Classes for Corn
All shares represent insured acres relative to planted acres (including prevented planting acres). High coverage is at least 75%, low buyup coverage is less than 75%. Optional Unit market shares also include Basic Unit acres. Enterprise Unit market shares also include Whole Farm Unit acres.

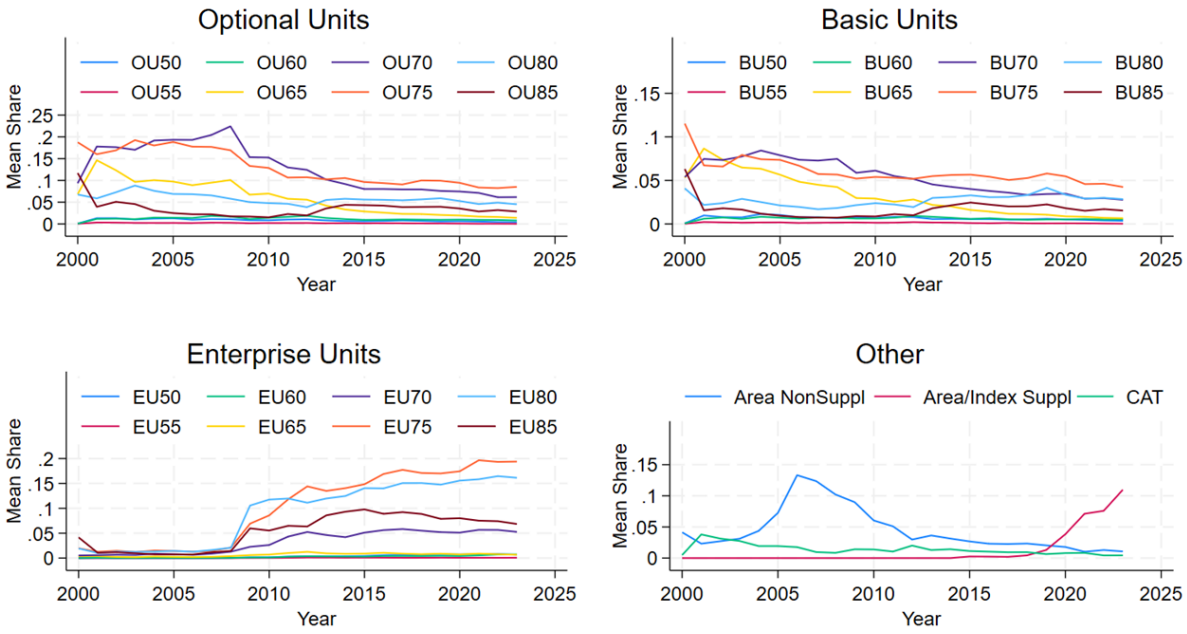


Figure 1b: Historical Mean Expenditure Shares of Crop Insurance Coverage Options
Share values are on the y-axis, years are on the x-axis. Historical county-level expenditure shares

are averaged cross-sectionally in each year. Upper left: optional unit coverage (50%–80%), legend colors by coverage level. Upper right and lower left: basic and enterprise units, respectively. Lower right: area non-supplemental, area/index supplemental, and CAT coverage, with legend colors.

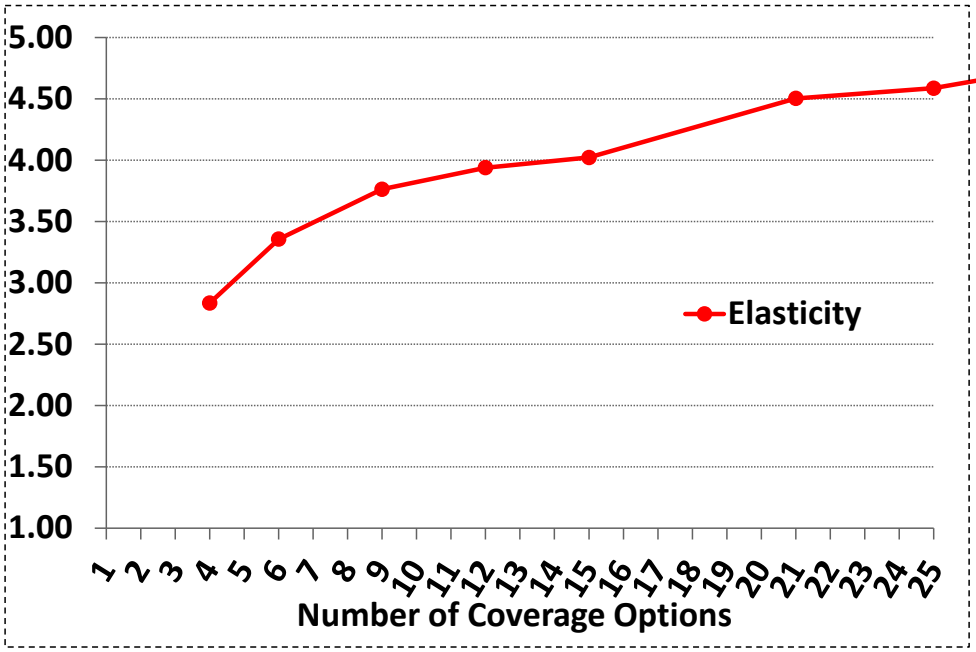


Figure 2a: Effect of Aggregation on the Values of the Elasticity with respect to Subsidy Rates. The estimated elasticity values are on the y-axis, and the number of coverage options analyzed is on the x-axis. The elasticity is for the total implied liability with respect to an additive change in subsidy rates in all coverage options except CAT. All estimates are under the symmetry cross equation restrictions. The elasticity values are obtained from the formulas given in equation (11).

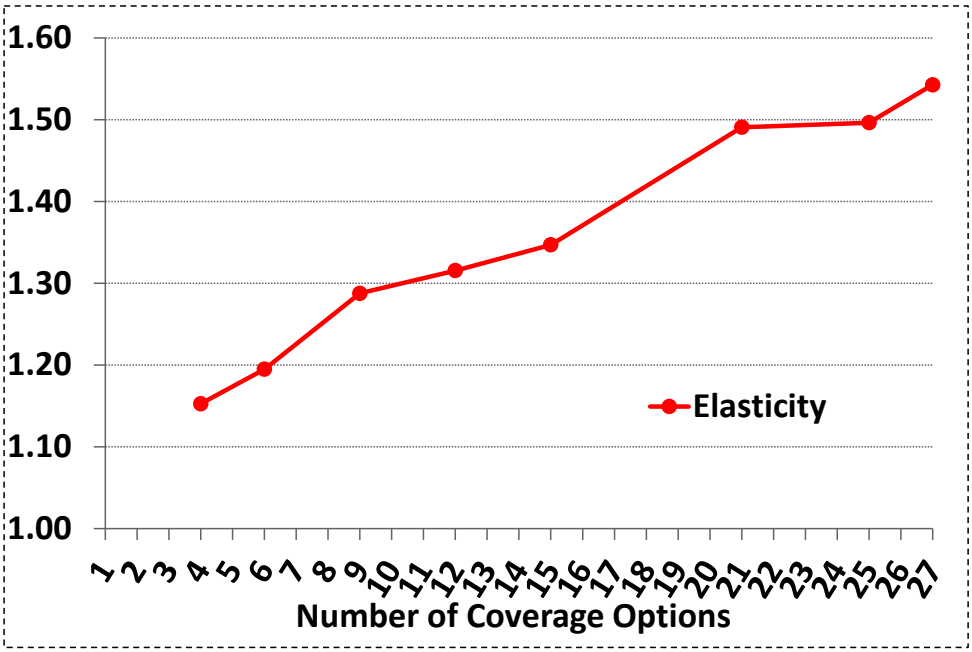


Figure 2b: Effect of Aggregation on the Values of the Elasticity with respect to Farmer-Paid Premium Rates. The estimated elasticity values are on the y-axis, and the number of coverage options analyzed is on the x-axis. The elasticity is for the total implied liability with respect to change in farmer-paid premium rates in all coverage options except CAT. Absolute values are reported. All estimates are under the symmetry cross equation restrictions. The elasticity values are obtained from the formulas given in equation (11), except that the terms with subsidy rates: $-1/(1-s_j)$ are dropped. .

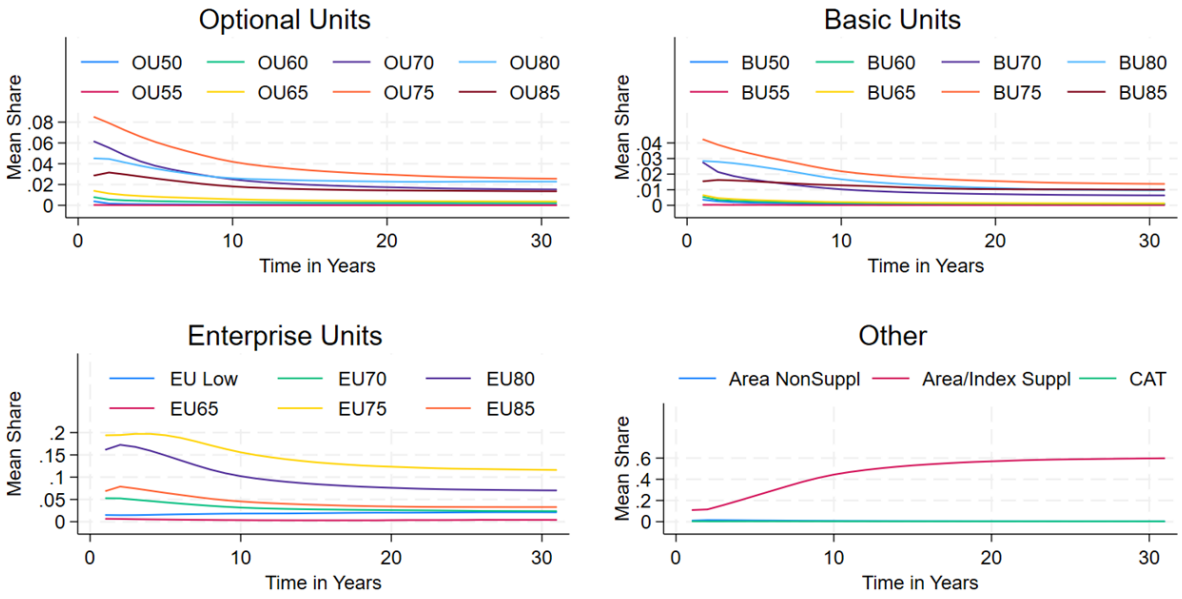


Figure 3. Projected mean expenditure shares with no subsidy rate change (baseline). Share values are on the y-axis, years are on the x-axis. Projected county-level expenditure shares are averaged cross-sectionally in each forecasting year. Upper left: optional unit coverage (50%–80%), legend colors by coverage level. Upper right and lower left: basic and enterprise units, respectively; 'EU Low' denotes the aggregate of EU (50%–60%). Lower right: area non-supplemental, area/index supplemental, and CAT coverage, with legend colors

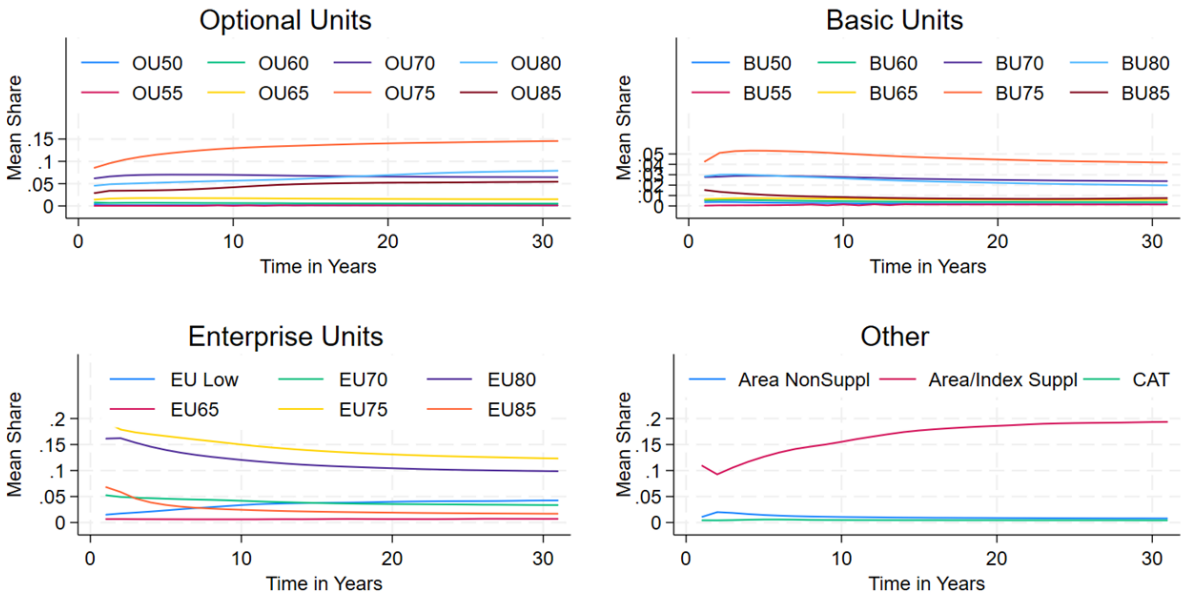


Figure 4: Projected mean expenditure shares under a 15 ppt buyup subsidy rate cut (CBO proposal). Share values are on the y-axis, years are on the x-axis. Projected county-level expenditure shares are averaged cross-sectionally in each forecasting year. See Figure 3 note for panel descriptions and legend definitions.

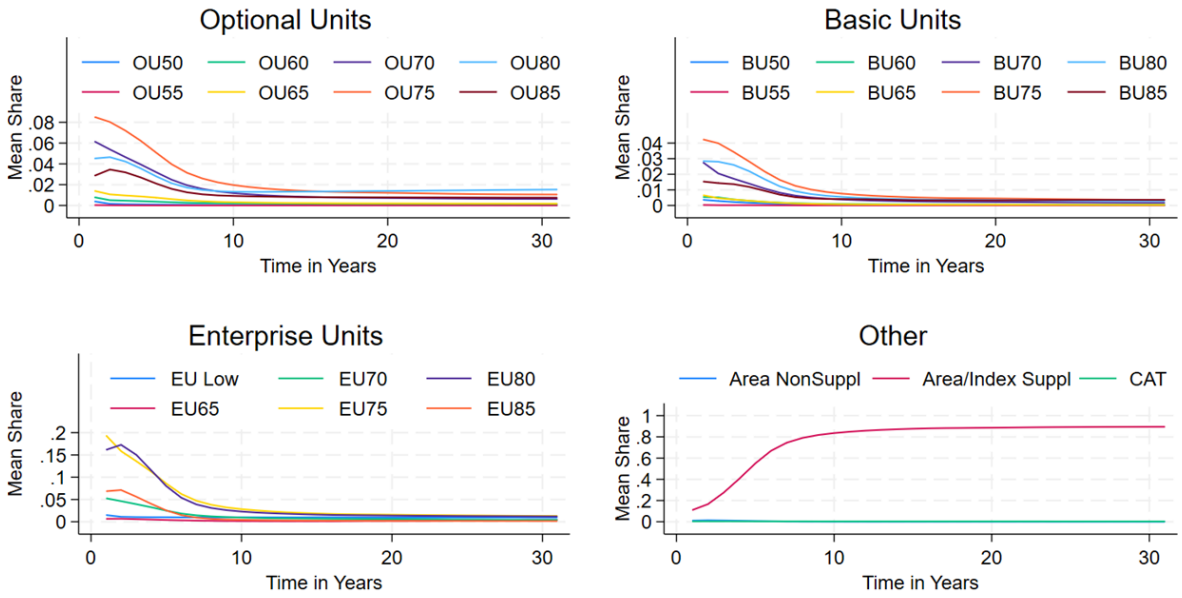


Figure 5: Projected mean expenditure shares under the 2025 Reconciliation Bill subsidy rate changes. Share values are on the y-axis, years are on the x-axis. Projected county-level expenditure shares are averaged cross-sectionally in each forecasting year. See Figure 3 note for panel descriptions and legend definitions.

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