Can an Informational Nudge Reduce Temporal Basis Risk in Pasture, Rangeland, and Forage (PRF) Insurance?

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Abstract

The Pasture, Rangeland and Forage Rainfall Index (PRF-RI) insurance program is a relatively new subsidized insurance product available to livestock and forage producers in the United States. Past research has shown that participants' policy choices have tended to increase their basis risk, or the risk that insurance indemnities do not correlate with on-farm forage outcomes. Basis risk has been shown to decrease demand for index insurance products like PRF-RI. This study conducts a monetarily incentivized framed-field experiment with livestock and forage producers in the northeastern U.S. to investigate behavior and decision-making in the PRF-RI program. We explore two main research questions: 1) Does an informational nudge about temporal basis risk increase enrollment in PRF-RI? 2) Does information about temporal basis risk nudge participants to make PRF-RI policy decisions that optimize forage loss mitigation? Results suggest that the temporal basis risk nudge increases participant enrollment in PRF-RI, but has no impact on the policy decisions related to basis risk.

Keywords

Pasture, Rangeland, Forage Insurance; Basis Risk; Nudge; Experimental Economics

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Introduction

The livelihoods of many livestock producers in the United States depend upon adequate rainfall for forage growth. In periods of drought, producers often face the decision to buy supplemental feed or forage versus cull the herd (Hrozencik, 2024). To mitigate such financial risk among livestock producers, the U.S. Department of Agriculture (USDA) Risk Management Agency (RMA) unveiled the pasture, rangeland, and forage (PRF) rainfall index-insurance in 2007 with availability in all 48 contiguous states in 2016. Participation in PRF has exponentially increased over time with 278 million acres insured in 2023 (Turner et al., 2024). The program is particularly popular in the Western United States, but certain regions such as the Northeastern United States remain underserved by the program (Turner et al., 2024).

One barrier to participation is program awareness, which is important to consider when evaluating enrollment decisions (Goodrich and Davidson, 2024). However, even among participants who are aware of and enrolled in PRF, coverage choices often fail to protect against forage losses. Enrolled producers tend to make policy selections that increase basis risk, undermining the effectiveness of the program in mitigating risk (Goodrich, Yu, and Vandeveer, 2020). Specifically, producers often choose to insure winter months when precipitation is less important to forage growth, yet indemnity payouts are maximized due to high variability in precipitation during winter months. The producer's choice to insure non-growing season months decreases the correlation between forage outcomes and indemnity payments, increasing temporal basis risk, a well-known component of total basis risk in weather index insurance products (Dalhaus and Finger, 2016).

Policy changes were recommended by academic literature (Cho and Brorsen, 2021; Coble et al, 2020; Westerhold et al., 2018) and ultimately proposed in 2020 to mitigate temporal basis risk in PRF through dropping non-growing season coverage options, i.e., eliminating two-month intervals in areas where precipitation in that period is of less value for forage growth (USDA RMA, 2020). However, these changes were not implemented after receiving public comment, likely due to intense political opposition to the changes (Babcock, 2011; Klein & Krohm, 2008). Such changes would have likely increased the cost of implementation, reduced the flexibility of the program, while also potentially increasing temporal basis risk if intervals were removed when precipitation does impact forage growth in an area. As an alternative to altering the PRF policy framework, Davidson and Goodrich (2023) suggested a behavioral nudge to improve interval selection but found limited effects through a hypothetical framed field experiment. While a nudge framing PRF as a risk management decision regarding forage loss increased enrollment in PRF, nudges on forage loss and probability of payment had no effect on the value placed in growing season months.

The current study further explores whether behavioral economics can be leveraged amidst PRF policy and outreach. We investigate the role of a temporal basis risk nudge on PRF enrollment and interval selection. The study employs a monetarily incentivized framed field experiment with

multiple rounds of decision-making. Specifically, a nudge designed to mitigate temporal basis risk prompts participants to enroll in months when precipitation will have the most impact on forage growth. Our results provide evidence that nudging is effective to increase enrollment but does not influence interval selection. However, prior enrollment in PRF is correlated with interval selections that increase temporal basis risk.

Previous work has shown that basis risk (Jensen et al. 2018; Elabed et al. 2013) and general contract complexity (Sibiko et al., 2018) undermine uptake of index insurance. With index insurance, many components of basis risk can be important in insurance uptake, e.g., design, spatial, temporal, and zonal (Dalhaus and Finger, 2016; Stigler and Lobell, 2024). Our study differs from previous research in that we investigate temporal basis risk specifically in an index insurance uptake decision. While others have studied exogenous temporal basis risk due to the frequency and timing mismatch between index triggers and actual losses (Dalhaus et al., 2018; Deng et al., 2007), here we investigate endogenous temporal basis risk that the farmer influences with policy decisions. Our study leverages a framed field experiment with a behavioral nudge to evaluate temporal basis risk in isolation; participants make policy decisions based on a hypothetical pasture where on-farm yields are exactly correlated to the rainfall index, eliminating spatial and design basis risk. Furthermore, policy decisions are preceded by program education in the experiment allowing participants to face simplified policy decisions with limited exogenous basis risk.

Previous experimental literature on index insurance has presented participants with binary decisions (e.g. whether to enroll in insurance) or simplified risk scenarios. For example, Giné, et al. (2008) examined rainfall insurance uptake in India using a binary (yes/no) decision, while Cole et al. (2013) studied how trust and financial literacy influenced similar binary decisions. Karlan et al. (2014) also evaluated weather insurance take-up in Ghana using straightforward purchase offers. Our study, more fully described in the experimental design section, is among the first to observe behavior in complex, multi-round decisions with observed outcomes. Participants select the time of year to enroll and observe multiple years of outcomes on insurance payouts and forage losses, exactly resembling real-world decisions over time.

In addition to literature and research contributions, our study offers evidence to inform policy. Findings imply behavioral nudges and educational outreach are effective methods to increase PRF enrollment in underserved areas. Particularly, producers are keen to adopt a tool to mitigate temporal basis risk in forage production given the right information. Nudging reduces the choice overload and complexity associated with PRF policy decisions while minimizing basis risk. Reducing basis risk through information is especially important for PRF enrollment since basis risk has been shown to decrease index insurance uptake (Miranda and Farrin, 2012). Additionally, the finding that producers who enrolled in PRF in previous years incur more temporal basis risk than their counterparts, paired with no evidence of learning across experimental rounds, suggests undue influence by crop insurance agents. This influence has been

understudied in the literature, and perhaps policy changes need to be made to properly align agent and farmer incentives with goals of RMA.

Background

PRF is an index-based rainfall insurance program offered through the U.S. Department of Agriculture (USDA) Federal Crop Insurance Program (FCIP) to protect livestock and forage producers against forage loss. Historic rainfall data from 1948 to two years prior to the present year are used to construct the rainfall index interval which pays indemnities when precipitation falls below historic averages. The index covers 0.25 latitude by 0.25 longitude grids (approximately 17 mi by 17 mi at the equator) determined by the National Oceanic and Atmospheric Administration Climate Prediction Center (NOAA, CPC).

To enroll in PRF producers determine the type of forage to insure (grazing or hay production), select a coverage level from 70 to 90 percent, and assign a percent-of-value to at least two index intervals reflecting the calendar year. Indices are offered in eleven two-month intervals, selections must be non-consecutive (i.e. non-overlapping), and percent-of-value is bounded from 10 to 50 percent in any interval. By design, the flexibility in interval selection allows producers to choose intervals when precipitation is most important for forage growth on their operation. Premium rates for each two-month interval and grid are determined individually to reflect differences in spatial precipitation risk across the calendar year. As with other federally supported crop insurance programs, premium rates for the PRF program are established by the Federal Crop Insurance Corporation (FCIC). The U.S. government subsidizes these premiums, with subsidy amounts varying based on the coverage level selected. To enroll, producers must purchase PRF through an authorized crop insurance agent.

Dalhaus and Finger (2016) classified three types of basis risk associated with index insurance products: design, spatial, and temporal basis risk. In the context of PRF, design basis risk encompasses how well on-farm rainfall correlates with on-farm forage yields, and spatial basis risk occurs when the grid-level rainfall index is not well correlated with on-farm rainfall, and temporal basis risk considers whether the time of year when the index triggers an indemnity is correlated with on-farm forage losses. Thus, in PRF temporal basis risk is influenced by the farmer's decision to allocate the percent-of-value across the eleven two-month intervals. The farmer can minimize temporal basis risk by choosing to insure time periods when a lack of precipitation will have an impact on forage growth, maximizing the correlation between the on-farm forage growth and the rainfall index. Conversely, choosing intervals when a lack of precipitation has little to no impact on forage growth maximizes temporal basis risk.

Experimental Design

This study evaluates whether a nudge can effectively mitigate temporal basis risk in PRF. We explore two null hypotheses:

1) *H_0: the temporal basis risk nudge has no impact on enrollment in PRF*

2) *H_0:the temporal basis risk nudge has no effect on percent of insured value allocated to growing season months*

To test these hypotheses, we conducted an incentivized experiment among livestock and hay producers in the northeastern United States. This study was approved by the institutional review boards at University of Delaware, University of California, Davis and, University of Illinois Urbana-Champaign, protocol numbers 2087313-2, 2122891-1, and 24-1718, respectively. Our experiment leveraged the actual design of PRF -- participants made monetarily binding decisions about a hypothetical pasture, described in detail below, while observing historical outcomes and information about forage loss.

Participants began the experiment by watching an educational video about PRF prepared by the co-authors in conjunction with University of Delaware Cooperative Extension. An informational nudge was administered through the videos; participants were randomly assigned to a treatment video or a control video. The treatment video contained basic information about PRF as well as an informational nudge about temporal basis risk (i.e. the importance of placing percent-of-value in months that are important to forage growth to correlate insurance indemnities with forage outcomes) with a practical example. The control video contained only basic information about PRF.

After the video, participants reviewed agronomic, economic, and precipitation information about a 20-acre pasture of cool season grasses in the Northeast to be used in the experiment. The information was based on historic data for a representative farm in Allegany County, Maryland, Grid 23605. The maximum production value was $55.30/acre, estimated based on the actual county base value from RMA data. Participants were informed that the most important months for forage growth were April, May, and June for this pasture. A table and chart were displayed to reveal the distribution of estimated losses per acre for the pasture from low rainfall based on 75 years (1948-2022) of historical rainfall index data (see Appendix). Forage losses were calculated for the pasture assuming a linear relationship with below average precipitation in the April through June intervals using historical rainfall index data collected from the USDA RMA Pasture, Rangeland, Forage Support tool.[1] Total forage losses were calculated each year as a weighted average of growing season intervals as follows (recall that the index normalizes the historical average precipitation for a two-month interval and grid to 100):

$$Total\ Forage\ Loss_t = \sum_{March-April}^{June-July} w_{int} * \min\left(0, \frac{100 - Precip_{int,t}}{100}\right) x\ \$55.30$$

where the weights, w_{int} , are: $w_{March-April}$= 16.67%, $w_{April-May}$ =33%, $w_{May-June}$ = 33% and $w_{June-July}$ =16.67%.

[1] https://public-rma.fpac.usda.gov/apps/PRF

Forage losses ranged from $0/acre up to $28.32/acre with an average loss over 75 years of $6.57/acre. Participants were informed that they would be making enrollment decisions about PRF for this sample pasture. All participants (treated and control) received the same information about the experimental pasture.

Enrollment decisions in the experiment were incentivized with real payment. 1 in 6 participants were selected for compensation paying $1 for every $12.50 in net returns in a randomly selected year (Net returns=maximum forage production value-forage losses + PRF indemnities-PRF premiums). On the decision screen participants in the treatment group were reminded of the temporal basis risk nudge with a statement in blue font[2]. Participants first selected the percent-of-value for each two-month interval, mimicking actual PRF enrollment decisions. The coverage level in the experiment was fixed at 90%, the most popular policy selection nationwide. After selecting percent-of-value allocations, the software program calculated premiums, subsidy level, and the premium paid by the producer. These figures were based on policy collected from the USDA decision support tool in 2022. The participant could choose to reset and recalculate data for another interval selection or proceed with their current policy choice. When their choices were finalized, the participant decided whether they wanted to purchase their selected policy for the 20-acre pasture. The participant made interval and enrollment decisions for six rounds representing different years. At the end of each round one year was randomly selected from the 75-year historical data. Outcomes for the selected year (i.e. forage losses and net returns) were calculated and displayed to the participant. Participants viewed a summary of outcomes for all rounds as the experiment progressed and could review detailed information of each previous round in case they wanted to review their past decisions.

In addition to the framed field experiment on PRF enrollment, participants completed an incentivized Holt-Laury risk preference elicitation. 1 in 6 participants were selected for real earnings in the risk elicitation, following Davidson and Goodrich (2023). In addition to written instructions,[3] a video explanation of the risk elicitation decision was available to participants. A post-experiment questionnaire also collected data on participant rankings about which months are important for rainfall in forage growth on their farm, farm production characteristics, awareness of PRF, intent to enroll their actual farm in PRF, past enrollment in PRF, and demographics. In total the duration of the video, experiment, and survey totaled approximately 30 minutes. All participants were compensated at least $10 for completing the experiment. Depending on outcomes and lottery selection in the experiment and the risk elicitation, participants could earn up to $185.

Data

[2] The reminder nudge read: “By enrolling in months when participation will have the most impact on forage growth, you minimize your forage production risk from low participation. This also reduces the chance of not receiving an insurance payout when forage loss occurs.”

[3] See Appendix.

Prior to data collection a statistical power analysis was conducted using *powertest* in Stata statistical software. Assuming $\beta = 80\%$ power and statistical significance $\alpha = 0.05$, at least 184 participants are required to detect a 0.42 standardized effect size which equates to a 10% increase in the percent-of-value placed in growing season months. Previous experimental research showed only 58% of participants enrolled in PRF (Davidson and Goodrich, 2023). Thus, to account for the number of participants who choose not to enroll we assumed a sample of 317 participants was needed for this experiment. The pre-analysis plan for this experiment was registered on aspredicted.org.

To mitigate well-known recruitment difficulties (Weigel et al., 2021) this study followed a multi-pronged recruitment approach from February 2024 through August 2025. Methods included a mailed invitation to participate online, emailed invitation to participate online, follow-up phone calls, recruitment at two regional farm shows, and personal outreach through extension networks. Mail, email, and phone lists were purchased from DTN and included all livestock or hay producers in the targeted states: Delaware, Maryland, New York and Pennsylvania. Our sample includes 183 participants.

Tables 1 and 2 present variable definitions and descriptive statistics of our participant sample. The majority, 70%, of the sample produced beef cattle and 38% produced dairy. Average farm size was 190 acres, which was consistent with the regional average farm size (USDA NASS, 2022). Only 18% of the sample had enrolled in PRF in previous years, and 53% of the sample had heard about PRF prior to this study. On average, 76% of participants' farm income came from livestock operations. The average age of producer in our study was 53 years old, slightly lower than the national average age (USDA NASS, 2022).

Empirical Methods

Following Heckman-style methods used by Smith and Baquet (1996), we model participant decisions as a two-step sample selection problem. In the first stage, the participant decides whether to purchase a PRF policy for the experimental pasture. In the second stage, the participant decides how to allocate percent-of-value across two-month intervals. This methodology allows us to identify an unbiased effect of the treatment on the percent-of-value allocation if the treatment also influences a participant's decision to enroll. The following equations, reflecting this two-stage decision, are estimated simultaneously using maximum likelihood equations (MLE):

$$Y^* = \boldsymbol{X}\beta + \varepsilon \tag{1}$$

$$Y = \begin{cases} 1 \; when \; Y^* > 0 \\ 0 \; when \; Y^* < 0 \end{cases} \tag{2}$$

$$P = \boldsymbol{X_1}\beta_1 + \mu \tag{3}$$

Y* is a latent indicator variable equal to 1 if the participant chooses to purchase the PRF policy and 0 if they would not purchase the insurance policy. P represents the percent-of-value assigned to growing season intervals, only observed when Y* = 1. Error term ε is assumed to be normally distributed with mean equal to zero and standard deviation equal to 1 and μ is an error term where $E[\mu|\varepsilon = \gamma\varepsilon]$. Indicator variables for the randomly assigned treatment are included in **X** in equation (1) and $\mathbf{X_1}$ in equation (3). **X** and $\mathbf{X_1}$ also contain other covariates expected to impact the decision to enroll and the allocation of the percent of value to growing season intervals, respectively. These covariates measure farmer risk aversion, farm characteristics, and demographics (described in table 1). **X** includes covariates that we expect to affect a participant's decision to enroll and $\mathbf{X_1}$ includes covariates that we expect to affect an individual's allocation decision for percent-of-value. To satisfy exclusion restrictions for the sample selection model, **X** must contain variables that would affect the enrollment decision but not the allocation decision, i.e., variables not included in $\mathbf{X_1}$.

We expect that acres of hay and pasture land (*Acres)*, the level of farm income (*Farm Income)*, the proportion of farm income coming from livestock production (*Prop Livestock Income*), the proportion of total hay used that is sold (*Prop Hay Sold*), participation in other livestock programs (*Other Livestock Programs),* e.g., the Livestock Indemnity Program (LIP) or Livestock Forage Disaster Program (LFP), and whether the farm is a fulltime endeavor (*Fulltime)* would impact the farm's risk exposure affecting the likelihood of enrollment in PRF (Sherrick et al., 2004; Goodwin, 1993; Coble et al., 1996; Smith and Baquet, 1996; Jose and Valluru, 1997; Roznik et al., 2019; Davidson and Goodrich, 2023; Goodrich and Davidson, 2024). We measured participant risk aversion (*Risk Aversion)* through an incentive compatible risk elicitation exercise (Akay et al., 2012; Eckel and Grossman, 2008; Holt and Laury, 2002) and expect that as risk aversion increases, the likelihood of enrollment in PRF would also increase. Prior enrollment in PRF (*PRF Prior)*, participation in other livestock insurance (*Other Livestock Insurance)*, e.g., Livestock Risk Protection (LRP) or Margin Protection Program for Dairy (MPP-Dairy), or other crop insurance programs like traditional yield or revenue protection policies (*Other Crop Insurance)* are likely to indicate a revealed preference for risk aversion and insurance uptake, increasing the likelihood of enrollment. Other variables like the number of years the participant has been farming (*Years Farming),* their education level (*Education),* whether the participant was familiar with PRF prior to the experiment (*Familiar),* and the state of residence (*State)* may influence their decision to enroll through various mechanisms. In the regression of the percent-of-value allocated to the growing season on the treatment variable and covariates, we expect that the measure of risk aversion (*Risk Aversion*), whether they had enrolled in PRF in a prior year (*PRF prior*), whether they were familiar with PRF (*Familiar),* and their education level (*Education)* might have an influence on the participant's allocation decision. Because each participant made independent enrollment decisions for six rounds, we include a round variable (*Round)* interacted with the treatment variable (*Treatment)* to account for learning effects and repeated exposure to the treatment across rounds.

Results

Figures 1 and 2 summarize the two outcome variables (enrollment and allocation of percent-of-value in the growing season) by treatment type. Figure 1 shows that participants in the treatment group enrolled in PRF 83% of the time, while those in the control group enrolled 70% of the time. This indicates that the treatment likely has an impact on a participant's decision to enroll, thus necessitating the sample selection procedures outlined in the previous section to identify any effect of the treatment on the percentage assigned to the growing season months.

Figure 2 shows the percent-of-value assigned to the growing season month intervals (March-April, April-May, May-June, June-July) by treatment versus control group. We observe little difference between the groups; on average the treatment group assigned 50% to the growing season intervals and the control group assigned 52% to those intervals.

Each participant engaged in six rounds of the PRF policy decision. Figures 3 and 4 summarize the outcome variables by round and treatment group. Figure 3 displays the percent of participants that enrolled by treatment type for rounds one through six. Across rounds, the relationship remains fairly similar, with the treatment group enrolling in PRF on average more frequently than participants in the control group.

Figure 4 displays box plots of the percent-of-value allocated to the growing season month intervals across rounds and treatment groups. Each square represents the average for each round and group. Figure 4 shows that the average for each group remains around 50% allocated to the growing season intervals across all rounds. During the later rounds, opposite of expected, the control group places slightly more coverage into growing season intervals than the treatment group. However, these differences are not statistically significant. Figure 4 suggests that the information treatment likely does not have a positive effect on the allocated coverage to growing season months as initially expected.

Table 3 displays the results of probit regressions exploring treatment effects on enrollment and growing season month allocation. Consistent with analysis of figures 1-4, the temporal basis risk nudge has a statistically significant and positive impact on PRF enrollment, but no statistically significant effect on the allocation of percent of insured value in growing season intervals. However, these probit regressions do not account for sample selection, i.e., a participant will not have a growing season interval allocation if they choose not to enroll. Thus, the estimate of the effect of the treatment on the growing season coverage allocation is likely biased given regression (1) in Table 3 shows an impact of the treatment on participant enrollment. To account for sample selection bias, Table 4 displays a Heckman-style sample selection regression (equation 1-3) for the effects of the treatment on the two variables of interest. Covariates are included to satisfy the exclusion restrictions of the sample selection regression framework.

Table 4 shows that the effect of the treatment on the decision to enroll in PRF is positive and statistically significant, while the treatment does not have any significant effect on the percent-of-value placed within the growing season intervals. This regression included all six rounds of decisions with a treatment by round interaction variable to account for learning over time and the repetition of the treatment nudge across rounds. There do not seem to be any learning or repetition effects, with *Round* and *Treatment x Round* coefficients being statistically insignificant.

Robustness Checks

For robustness, we include regressions of the first and last individual rounds in the Appendix (Tables A1 and A2). Results for the individual rounds are consistent, with the treatment increasing the likelihood of enrollment, with no impact on the percent-of-value allocation.

We also recognize that participants were asked to make an enrollment decision for a hypothetical pasture, while simultaneously having beliefs about when precipitation matters for forage growth in their own pasture production. Thus, we include a robustness check using responses to a supplemental question about growing season months in the survey. Participants were asked to identify at least three months in which below average precipitation would have a negative impact on forage growth for pasture on their operation. They were then asked to rank those months from most to least important. From this data we constructed a variable for the top three important months, calculating the percent-of-value they placed in intervals overlapping with those important months. Figure A1 in the Appendix displays the distribution of participant responses for the most important months, and table A3 in the Appendix shows the results of the sample selection regression using the participant-defined growing season interval. Results are consistent with those in table 4, showing a positive effect on enrollment and no effect on the percent-of-value allocated to their own growing season. It is noteworthy that some learning appeared to occur over time where the participant placed less percent-of-value in their own growing season. Given that the second and third highest reported months (July and August in Figure A1) were outside of the defined growing season for the hypothetical farm, this may indicate movement toward placing percent-of-value in hypothetical farm's growing season, or towards intervals outside the hypothetical or own growing season all together.

Past enrollment in PRF

The effect of past enrollment in PRF on the outcome variables also have important policy implications. Those who enrolled in PRF in prior years were more likely to enroll in PRF during the experiment. This is consistent with the findings of loyalty effects in other crop insurance programs, as well as in PRF (Enjolras and Sentis, 2011; Uzea et al 2014a, 2014b, Davidson and Goodrich, 2023).

With respect to the percent-of-value allocation decision, only one variable was statistically significant in Table 4 as well as in all the robustness checks: Prior PRF participation led to a

decrease in the percentage of value allocated to the growing season months. This behavior aligns with findings of prior work on PRF, showing that participants often enroll in non-growing season months in an effort to capitalize on subsidies (Cho and Brorsen, 2021; Goodrich, Yu, Vandeveer, 2020; Westerhold et al., 2018). Familiarity with PRF prior to participating in our study did not have a significant affect on their allocation decisions. Thus, prior participants have gained some information changing their allocation decisions through their past participation, likely reflecting engagement with crop insurance agents.

To further explore the influence of crop insurance agents, the post-experiment survey asked participants supplemental questions about how they would make their PRF decisions. Figures 5 and 6 display the results. Nearly 90% of participants responded that they would rely on their crop insurance agent to some extent when making PRF decisions, with over half of participants falling into the top two levels (4 and 5) of stated reliance (Figure 5). When asked specifically about how they would choose two-month intervals to enroll in, roughly 44% stated they would use recommended intervals from their crop insurance agent (Figure 6). The most popular response (74% of respondents) was to "choose intervals that are important to the forage growing season," i.e., those that would minimize temporal basis risk. However, when separating this out by prior PRF participants and non-participants, this result is driven primarily by those who have not enrolled in PRF before. Less than half of prior PRF participants chose intervals according to the forage growing season.

Discussion/Policy Implications

Findings from this study offer important insights for USDA RMA when considering PRF program design and promotion. In particular, our study highlights the importance of emphasizing forage loss mitigation through PRF. To increase program enrollment policymakers and extension educators should focus efforts on reminding producers that PRF is a tool to reduce the financial losses incurred from low rainfall in growing season months. However, contrary to our hypothesis, information about temporal basis risk does not influence participant decisions to enroll in months that are important to forage growth. This remains consistent across rounds; even as participants gain experience with PRF enrollment and outcomes over time, the nudge does not encourage optimal risk mitigating behavior.

While our experimental evidence does not show learning effects across rounds, we find a correlation between previous experience with PRF and enrollment decisions. Participants who had enrolled their own acreage in PRF in the past were more likely to enroll in PRF in the experiment. Interestingly, experience with PRF decreases the likelihood that a farmer chooses coverage during growing season months in the experiment. We suspect this reflects the advice

farmers have received while engaging with crop insurance agents during actual enrollment.[4] Specifically, an incentive alignment problem exists in PRF where crop insurance agents have incentive to encourage participants to enroll in months with the highest probability of receiving indemnities. Crop insurance agents are often compensated as a proportion of the total premiums collected, and because RMA sets premium rates, offering the highest probability of an indemnity payment is one of the few ways agents can compete for farmer's business. Thus, PRF participants are prone to subsidy harvesting rather than enrolling in months that optimize risk mitigation (Cho and Brorsen, 2021; Goodrich, Yu, Vandeveer, 2020; Westerhold et al., 2018). Our findings show a behavioral nudge is not sufficient to overcome this tendency.

Further research assessing the role of crop insurance agents on PRF enrollment would benefit RMA policymakers. The results from the follow-up question on crop insurance reliance reveals the importance of crop insurance agents in decision-making for this complex tool. Because farmers rely so heavily on crop insurance agents, it is important for policymakers to understand whether agent behavior and incentives align with RMA objectives for PRF. To our knowledge, very few studies have investigated the role of crop insurance agents in farmer decision-making (Smith, Glauber and Dismukes, 2016; Delay et al., 2020; Delay and Walters; 2024).

The current findings align with previous studies on PRF enrollment that stress the importance of program education and participant awareness (Davidson and Goodrich 2024; Davidson and Goodrich, 2023). The USDA should continue to invest in risk management education initiatives to promote PRF. It is crucial that these initiatives highlight the role of PRF at mitigating forage loss to increase enrollment, particularly in underserved areas. Furthermore, education programs should target crop insurance agents in addition to livestock and hay producers. Finally, future research should explore alternative behavioral economics methods such as default intervals to reduce the incidence of subsidy harvesting.

Finally, the consistency of results compared to Davidson and Goodrich (2023) suggest a well-designed hypothetical framed field experiment that controls for hypothetical bias may perform as well as a monetarily incentivized framed field experiment. Future experimental research should rigorously compare incentivized versus hypothetical design for framed field experiments among farmers.

Conclusion

PRF rainfall index insurance can protect livestock and forage producers from severe financial losses incurred during periods when precipitation is lacking. However, in some regions of the U.S., program awareness is low, and in regions with higher enrollment, policy decisions tend to

[4] For example the following two companies market PRF guaranteeing the "best return" from the insurance rather than the best risk management return: Redd Summit Advisors (https://www.youtube.com/watch?v=7zx0UrY2mTc) and Silveus Insurance Group(https://www.silveuscropins.com/pasture-rangeland-and-forage/).

be sub-optimal from a risk management perspective. This study explored the potential for a behavioral nudge to increase program enrollment and improve policy selections. In a monetarily incentivized framed field experiment among livestock and forage producers in the northeastern United States, participants made enrollment and policy decisions for a hypothetical pasture while observing historical outcomes. Participants were randomly assigned to a behavioral nudge treatment about temporal basis risk and the importance of allocating PRF percent-of-value to months that are important for forage growth. The control group received basic information about PRF with no nudge. Our findings show that the temporal basis risk nudge increased the likelihood a participant would enroll in PRF, but we find no significant effect on percent-of-value allocation to growing season months. Survey results also highlight the importance of crop insurance agents in the PRF decision-making process and the loyalty effect of previous enrollment in the program.

These findings inform policymakers about the importance of emphasizing risk mitigation behavior during outreach and communication about PRF. Further research is needed to explore whether behavioral economics can be leveraged among crop insurance agents to optimize participant policy selections.

Tables

Table 1. Description and Values of Covariates

Covariate	Description	Values
Risk aversion	Constant relative risk aversion (CRRA) measured through a risk elicitation exercise with real payouts following Akay et al. (2012), Eckel and Grossman (2008), and Holt and Laury (2002). Participants choose between a certain bet with a small payoff and a risky bet with a large payoff.	CRRA values calculated by the certainty-equivalent mid-point value at which a participant decided to switch from the sure payoff to the lottery. Possible CRRA values: -0.4, -0.2, -0.1, -0.03, 0.03, 0.1, 0.17, 0.24, 0.3, and 0.4
Acres (thousands)	Continuous variable equal to the participants' total number of acres dedicated to pastureland and hay production	Number of acres (in thousands)
Farm income	Integer ranging from 1 to 7 representing the participants' agricultural gross sales in the previous year	Gross Sales Categories: (1) <$5,000 (2) $5,000-$9,999 (3) $10,000-$24,999 (4) $25,000-$49,999 (5) $50,000-$99,999 (6) $100,000-$249,999 (7) >$250,000
Prop Livestock Income	Average proportion of net farm income coming from livestock and hay production	Proportion calculated as the sum of the proportion of total farm income from livestock and the proportion of total farm income from hay
Prop Hay Sold	Proportion of hay sold off-farm vs. used on farm last year	Proportion calculated as the amount of hay sold divided by the total amount of hay produced
Years Farming	Continuous variable equal to the number of years the participant has been farming	Number of years
PRFprior	Binary variable indicating whether the participant had enrolled in PRF in a previous year	Indicator variable equal to 1 if the participant had enrolled in PRF in previous years and 0 otherwise
Familiar	Binary variable indicating whether the participant had heard of PRF prior to this experiment	Indicator variable equal to 1 if the participant had heard about PRF prior to the experiment and 0 otherwise
Other Crop Insurance[l]	Categorical variable indicating other crop insurance programs in which the participant is enrolled.	Categories: (1) NAP[±] (2) Yield or Revenue protection for field or specialty crops (3) Not enrolled in any other insurance programs

Table 1. Continued

Covariate	Description	Values
Other Livestock Insurance	Binary variable indicating if the participant has previously enrolled in other insurance programs offered for livestock producers by USDA RMA. The programs include: Livestock Risk Protection (LRP), Livestock Gross Margin Insurance (LGM), Margin Protection Program for Dairy (MPP-Dairy), or Dairy Revenue Protection (Dairy-RP)	Indicator variable equal to 1 if the participant had enrolled within the last 10 years in any of the insurance programs and 0 otherwise
Other Livestock Programs	Binary variable indicating if the participant has previously participated in any USDA livestock disaster programs. These programs include: Livestock Indemnity Program (LIP), Livestock Forage Disaster Program (LFP), Emergency Assistance for Livestock, Honey Bees, and Farm Raised Fish (ELAP).	Indicator variable equal to 1 if the participant had enrolled within the last 10 years in any of the disaster programs and 0 otherwise
Education	Integer ranging from 1 to 7 representing the highest degree of education the participant had completed	Education Level: (1) Less than high school (2) High school diploma or GED (3) Some college (no degree) (4) Technical or Vocational school (5) Bachelor's degree (6) Master's degree (7) PhD
Fulltime	Binary variable indicating whether the participant identifies as a full-time or part-time farmer	Indicator variable equal to 1 if the participant identifies as a full-time farmer and 0 otherwise
Round	Experimental PRF enrollment decision round	Integer from 1 to 6

Notes:

[±]Denotes reference category in regression

[1]Some producers enrolled in NAP and Yield or Revenue protection for field or specialty crops, these producers were put into the Yield or Revenue protection category for *OtherInsurance.*

Table 2. Summary Statistics

Statistic	N	Mean	St. Dev.	Min	Max
Treatment	183	0.54	0.50	0	1
Risk Aversion	165	0.08	0.23	-0.40	0.40
Beef Cattle	183	0.70	0.46	0	1
Dairy	183	0.38	0.49	0	1
Hay Only	183	0.04	0.21	0	1
Other Livestock	183	0.35	0.48	0	1
Acres (in 1000s)	164	0.19	0.24	0.005	2.00
Farm Income Category	161	4.89	1.89	1	7
Proportion Livestock Income	159	0.76	0.33	0.01	1.00
Proportion Hay Sold	162	0.23	0.33	0.00	1.00
PRF Prior	165	0.18	0.39	0	1
Familiar	165	0.53	0.50	0	1
Other Livestock Insurance	165	0.40	0.49	0	1
Other Livestock Programs	165	0.24	0.43	0	1
Fulltime	165	0.65	0.48	0	1
Age	161	53.28	15.30	21	84
Years Farming	162	29.11	16.51	2	82
Education	161	3.89	1.53	1	7
Other Insurance: NAP	161	0.07	0.25	0	1
Other Insurance: Not Enrolled	161	0.59	0.49	0	1
Other Insurance: Yield or Revenue	161	0.34	0.48	0	1
Delaware	183	0.05	0.23	0	1
Maryland	183	0.15	0.36	0	1
New York	183	0.31	0.46	0	1
Pennsylvania	183	0.49	0.50	0	1

Table 3. Probit Regressions of Enrollment and Percent Allocated to Growing Season on Treatment

	Dependent variable:	
	Purchased PRF % in Growing Season	
	(1)	(2)
Treatment	0.42*** (0.09)	-0.07 (0.09)
Constant	0.54*** (0.06)	0.06 (0.07)
Observations	1,070	826
Log Likelihood	-562.66	-576.49
Akaike Inf. Crit.	1,129.31	1,156.98
Note:		*p<0.1; **p<0.05; ***p<0.01

Table 4. Sample Selection Regression of Enrollment and Percent Allocated to Growing Season on Treatment

	Dependent variable:	
	Purchased PRF % in April-June	
	(1)	(2)
Treatment	0.39* (0.24)	0.002 (0.04)
Round	-0.03 (0.04)	-0.004 (0.01)
Risk Aversion	0.03 (0.22)	-0.05 (0.04)
Acres (thousands)	-0.18 (0.28)	
Farm Income	-0.07* (0.04)	
Prop Livestock Income	0.16 (0.17)	
Prop Hay Sold	-0.05 (0.16)	
PRF Prior	1.14*** (0.30)	-0.22*** (0.03)
Familiar	0.14 (0.12)	0.03 (0.02)
Other Crop Insurance: Not Enrolled	0.47** (0.24)	
Other Crop Insurance: Yield or Revenue	0.66*** (0.24)	
Other Livestock Insurance	0.21 (0.13)	
Other Livestock Programs	0.23 (0.18)	
Fulltime	0.40*** (0.14)	
Years Farming	0.005 (0.004)	
Maryland	1.15*** (0.30)	
New York	0.65** (0.31)	
Pennsylvania	1.10*** (0.30)	
Education	0.23*** (0.04)	-0.01 (0.01)
Treatment x Round	0.03 (0.06)	-0.01 (0.01)
Constant	-2.03*** (0.46)	0.63*** (0.06)
Observations		948
Log Likelihood		-387.95
ρ		-0.28 (0.25)
Note:		*p<0.1; **p<0.05; ***p<0.01

Figures

Figure 1. Percentage Enrolled in Insurance by Treatment Type

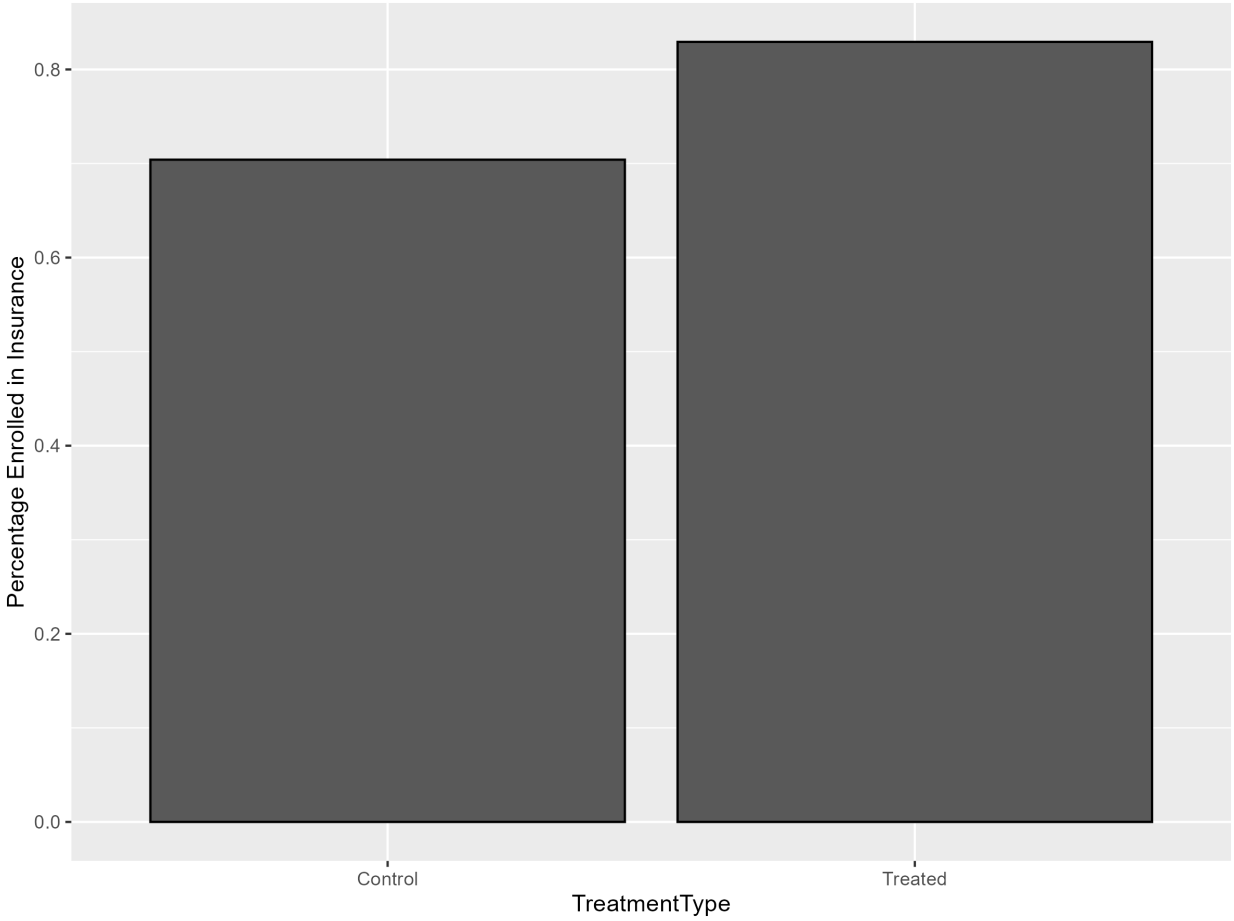


Figure 2. Percentage of Coverage Enrolled in Growing Season by Treatment Type

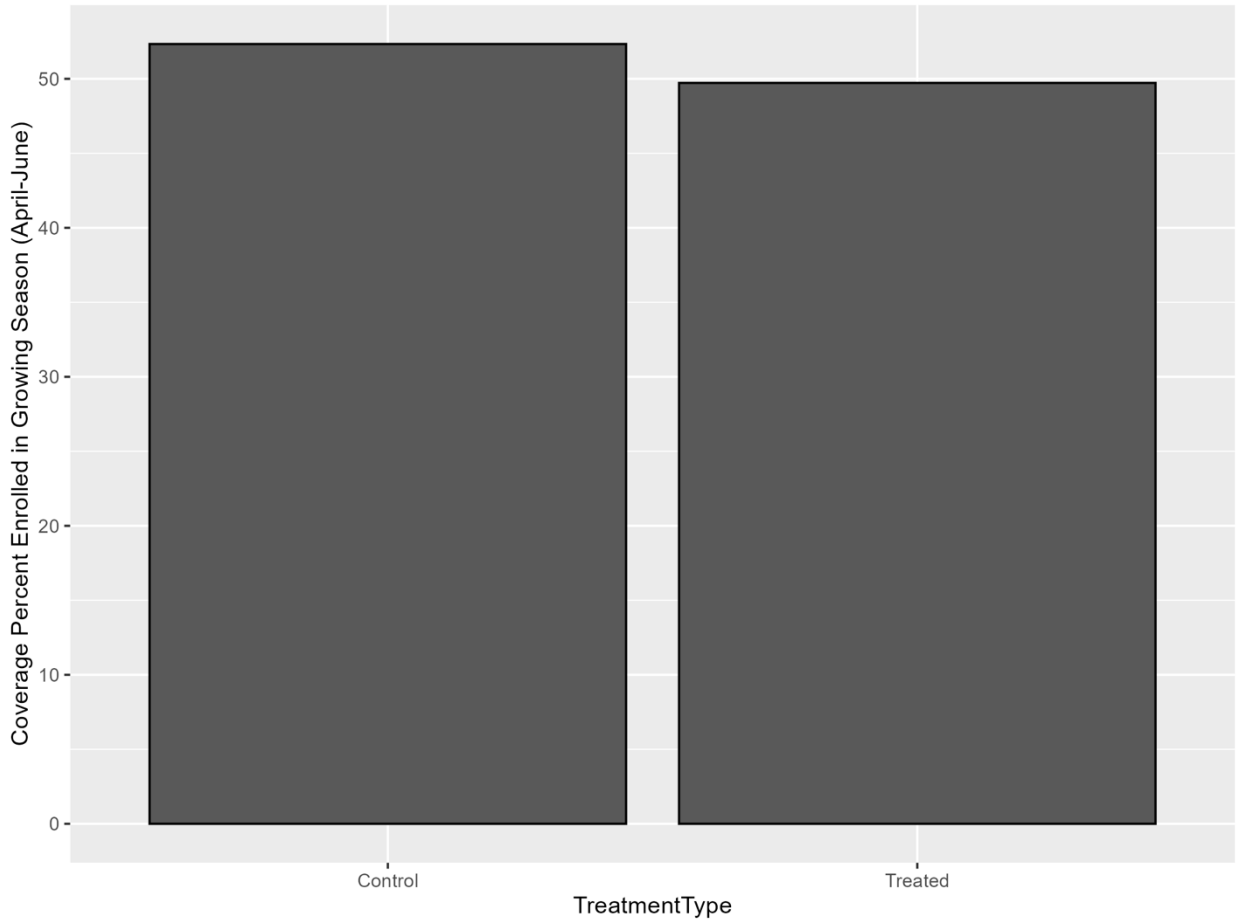


Figure 3. Percentage Enrolled in Insurance by Treatment Type and Round

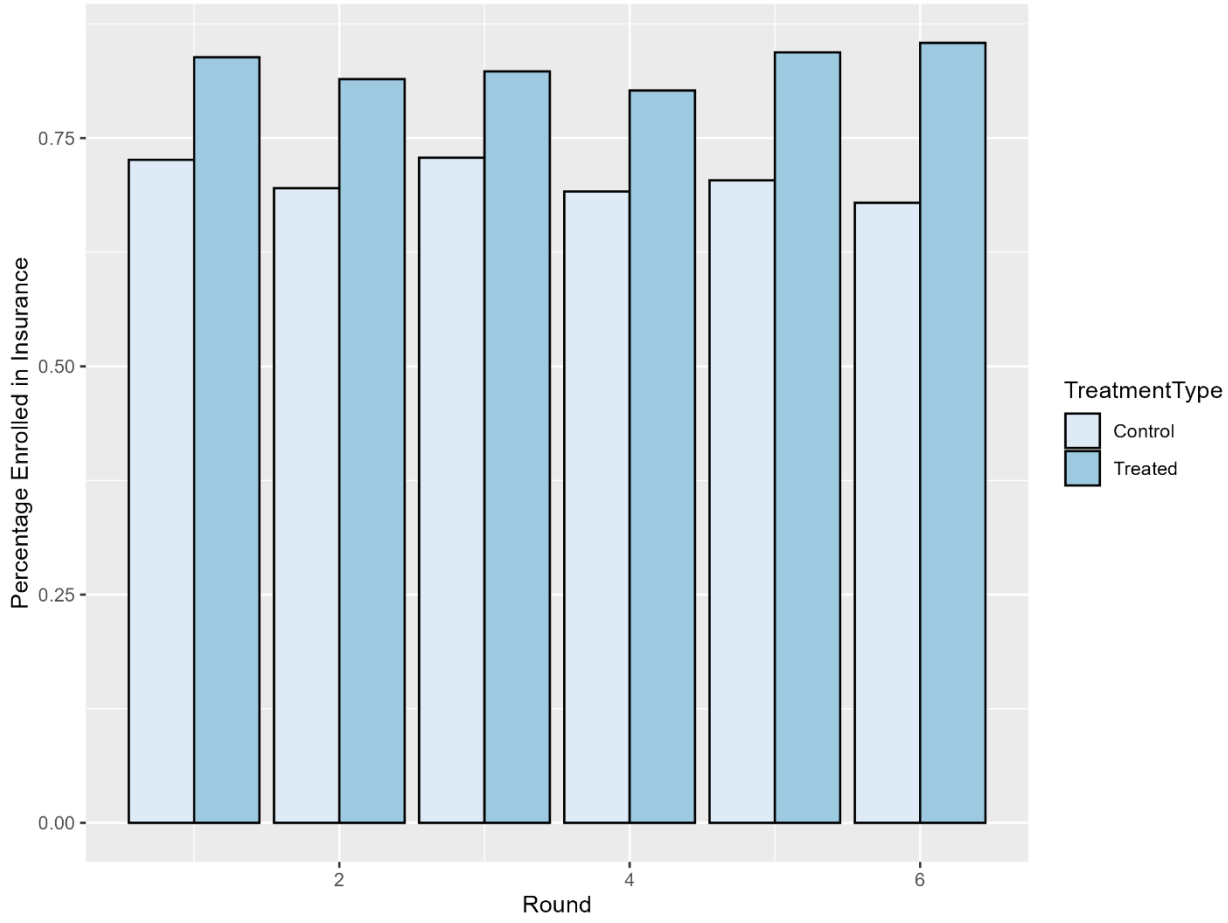
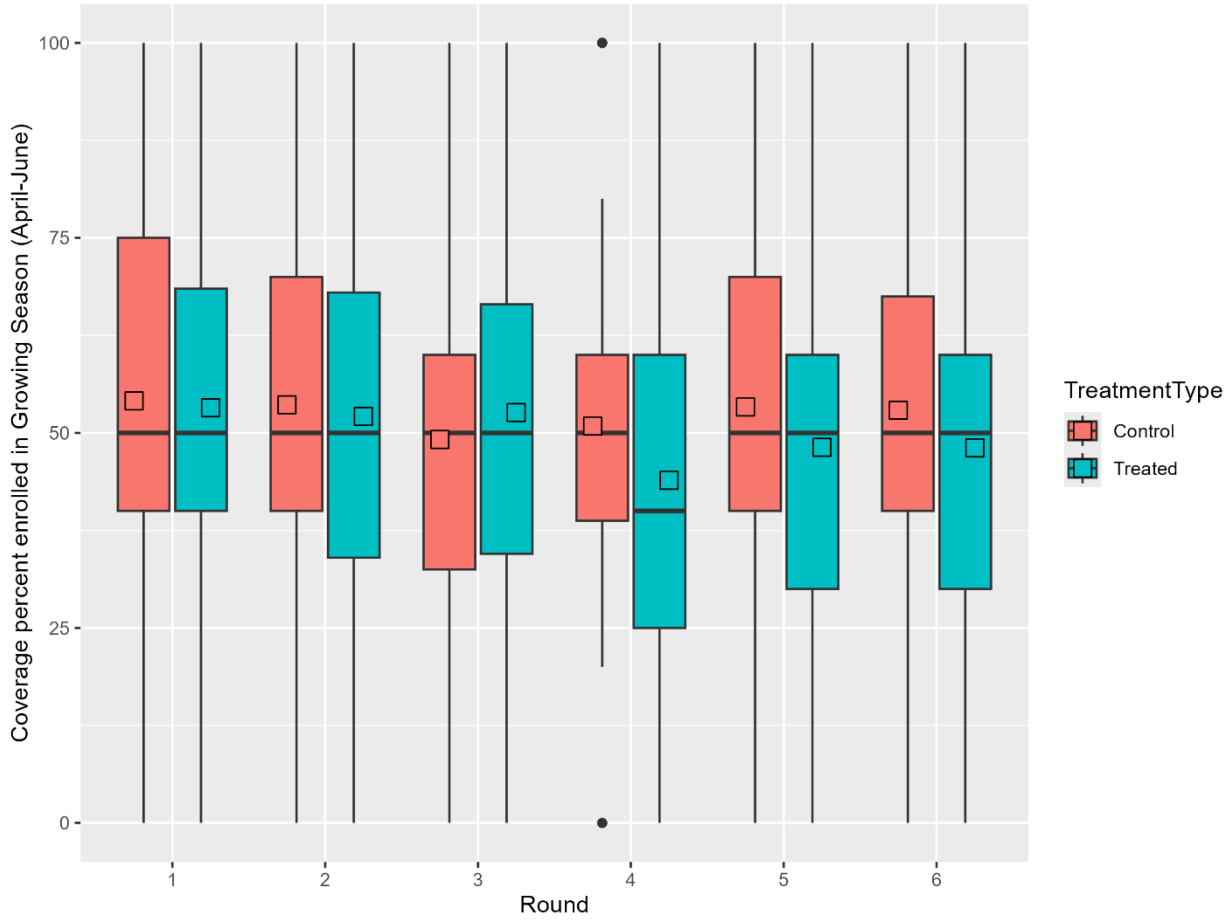


Figure 4. Box plots of Percentage of Coverage Enrolled in Growing Season by Treatment Type and Round



Note: Square represents the average for the round and treatment group.

Figure 5. Percentage of responses to, “How much would you rely on your crop insurance agent for advice on making PRF decisions?”

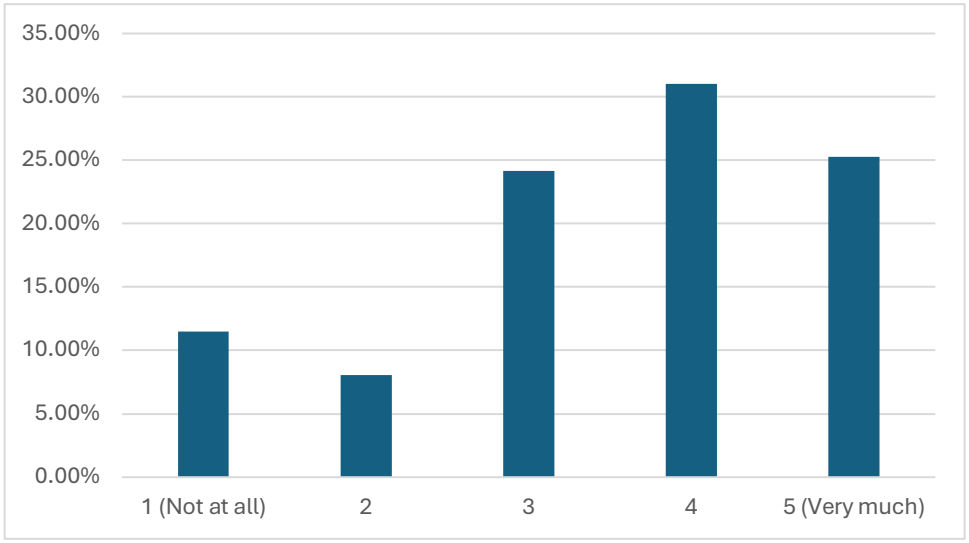
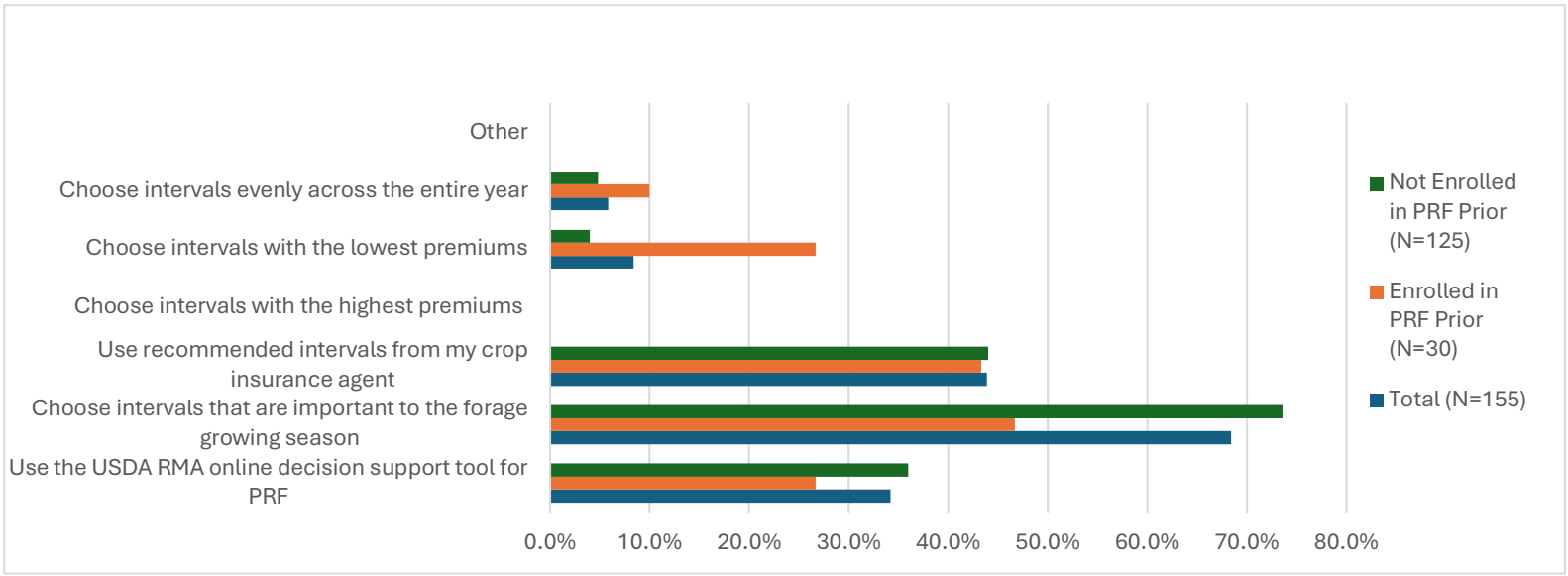


Figure 6. Percentage of responses to, “If you were to enroll in PRF insurance, how would you select the two-month intervals to enroll?”



Appendix

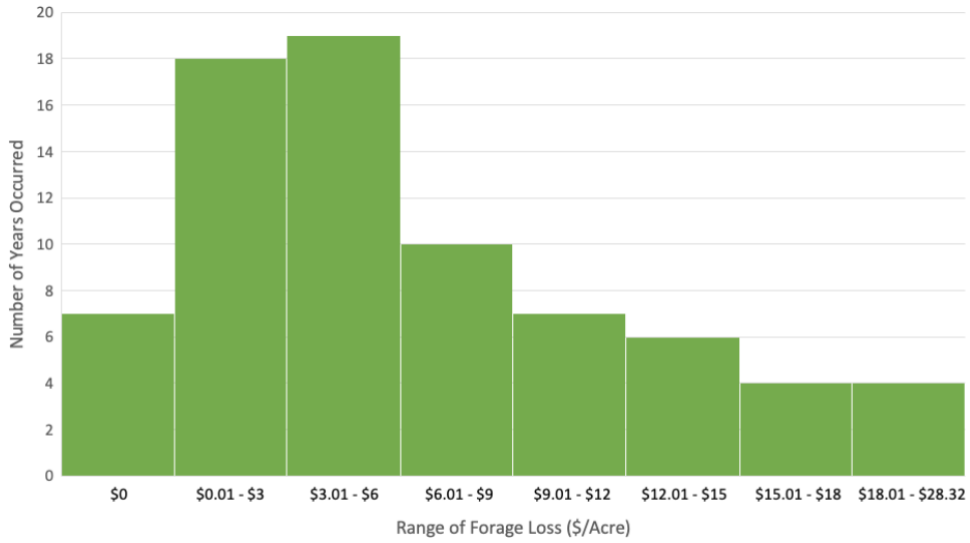
Hypothetical Pasture Information Provided to All Participants

Pasture Information:

Imagine you manage a 20-acre pasture of cool season grasses in the Northeast. This pasture is not irrigated and not organic. The maximum production value of this pasture in a good rainfall year is estimated at $55.30/acre. Rainfall varies from year to year, so when rainfall is below average in months important for forage growth, the production value of the forage decreases. For this pasture, the months when rainfall is most important for forage growth are April, May, and June.

Using 75 years of NOAA rainfall data for the region, the following table and chart represent the estimated losses per acre for this pasture from low rainfall. Losses range from $0/acre up to $28.32/acre. In 44 of the 75 years, losses are less than $6/acre. The average loss over 75 years is $6.57/acre.

Range of forage losses from low rainfall ($/acre)	Number of years loss occurred
$0 (No Loss)	7
$0.01 - $3	18
$3.01 - $6	19
$6.01 - $9	10
$9.01 - $12	7
$12.01 - $15	6
$15.01 - $18	4
$18.01 - $28.32	4



Back Continue

Written instructions for Risk Elicitation Decision

- In this part of the study, you will be asked to make a set of decisions.
- In this part of the study, one out of every six participants will be randomly selected to earn up to $40, depending on their choices. You may be the participant that is selected, so make your decisions carefully.
- You will be shown a list of 10 paired choices. For each of the 10 paired choices you will be choosing between Option A: to play a lottery where you could earn $40 or $0 versus Option B: to not play the lottery but instead choose a guaranteed payment that increases in value as you move down the list of choices.
- You may decide to first choose Option B in the first paired choice or in any other choice in the list. However, you may only switch from choosing Option A to choosing Option B (or vice versa) one time. Therefore, **your task is to decide when you want to choose Option B over Option A as you move down the choice list.**
- After you have made your decisions, the computer will randomly select (a) one of the ten paired choices, (b) a white ball or an orange ball for the lottery and (c) whether or not you will earn real cash.
    - Selection of each paired choice in this session is equally likely.
    - One in six participants will be randomly selected to earn real cash. The payment will correspond to the participant's selection (A or B) in the randomly selected paired choice.

Below is an example of the decision screen. In this example you see 3 choices but on the next screen you will see 10 paired choices where you will select option A or option B.

The payoff for choosing Option A depends on the lottery. The computer will simulate a random draw of a lottery ball from a virtual basket. If the ball is orange, you get $40. If the ball is white, you get $0.

Option B is a guaranteed amount – you choose not to play the lottery but instead accept the guaranteed payoff.

Your decision is when to switch from Option A (playing the lottery) to Option B (choosing a guaranteed payoff). Choose Option B at the point when you prefer Option B to Option A. This can be any choice in the list of 10.

Please remember that your decisions are real as there is a one in six chance you will be randomly selected to earn real cash – either $40 or the amount you select in Option B.

Choice	Option A (Play the lottery)		Option B (Guaranteed payoff)	Your Decision
	The likelihood/chance of a white ball being drawn is: X%	The likelihood/chance of an orange ball being drawn is: Y%		
	Payoff if white ($)	Payoff if orange ($)	Payoff ($)	
1	0	40		A ○ ○ B
2	0	40		A ○ ○ B
3	0	40		A ○ ○ B

What will your earnings be from this part of the study?

Example: If you are the one of six randomly selected participants to earn real cash, one of the 10 paired choices will be selected to determine the earnings. Suppose choice 2, shown in the table above, is randomly selected. If you chose Option B (the guaranteed payoff) in the 2nd choice in the list, you will receive an additional $13.73 in earnings. If you chose Option A (the lottery), the computer will select one ball out of a virtual basket. If the ball is orange, you will receive $40. If the ball is white, you will receive $0.

Table A1. Sample Selection Regression of Enrollment and Percent Allocated to Growing Season on Treatment, Round 1

	Dependent variable:	
	Purchased PRF % in April-June	
	(1)	(2)
Treatment	0.60** (0.30)	0.07 (0.05)
Risk Aversion	0.75 (0.51)	-0.16 (0.10)
Acres (thousands)	-0.85* (0.49)	
Farm Income	0.06 (0.09)	
Prop Livestock Income	-0.47 (0.40)	
Prop Hay Sold	-0.01 (0.38)	
PRF Prior		-0.22*** (0.06)
Familiar	-0.51* (0.30)	-0.03 (0.05)
Other Crop Insurance: Not Enrolled	0.21 (0.57)	
Other Crop Insurance: Yield or Revenue	0.24 (0.57)	
Other Livestock Insurance	0.42 (0.30)	
Other Livestock Programs	0.37 (0.34)	
Fulltime	0.64** (0.31)	
Years Farming	0.01 (0.01)	
Maryland	0.97 (0.72)	
New York	-0.04 (0.57)	
Pennsylvania	0.58 (0.56)	
Education	0.36*** (0.10)	0.01 (0.02)
Constant	-1.74* (0.97)	0.59*** (0.09)
Observations		158
Log Likelihood		-75.55
ρ		-0.74*** (0.11)
Notes:		*p<0.1; **p<0.05; ***p<0.01

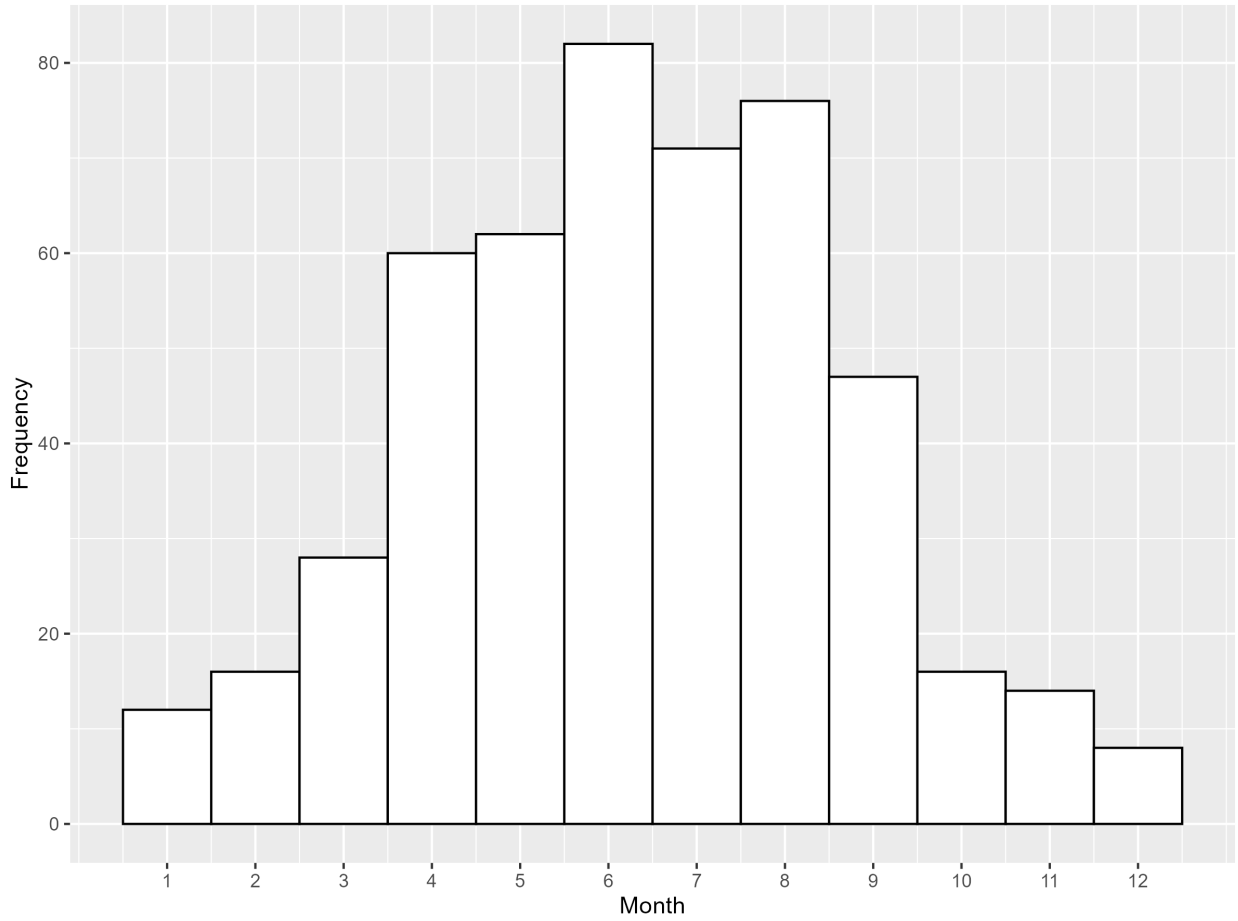
Prior enrollment in PRF was dropped from round-specific enrollment regressions due to multicollinearity issues.

Table A2. Sample Selection Regression of Enrollment and Percent Allocated to Growing Season on Treatment, Round 6

	Dependent variable:	
	Purchased PRF % in April-June	
	(1)	(2)
Treatment	0.63** (0.28)	-0.04 (0.07)
Risk Aversion	0.51 (0.57)	0.01 (0.10)
Acres (thousands)	-0.76 (0.66)	
Farm Income	-0.15 (0.11)	
Prop Livestock Income	0.64 (0.44)	
Prop Hay Sold	0.23 (0.41)	
PRF Prior		-0.16** (0.06)
Familiar	0.26 (0.28)	-0.05 (0.06)
Other Crop Insurance: Not Enrolled	-0.04 (0.59)	
Other Crop Insurance: Yield or Revenue	0.31 (0.64)	
Other Livestock Insurance	0.15 (0.34)	
Other Livestock Programs	0.95* (0.51)	
Fulltime	0.61* (0.36)	
Years Farming	0.01 (0.01)	
Maryland	1.54* (0.90)	
New York	0.53 (0.69)	
Pennsylvania	0.85 (0.68)	
Education	0.21** (0.09)	0.002 (0.02)
Constant	-1.97* (1.07)	0.59*** (0.19)
Observations		158
Log Likelihood		-63.56
ρ		-0.09 (1.00)
Note:		*p<0.1; **p<0.05; ***p<0.01

Prior enrollment in PRF was dropped from round-specific enrollment regressions due to multicollinearity issues.

Figure A1. Histogram of participants indicating months when a lack of rainfall may impact forage growth



Note: Each participant selected three months

Table A3. Sample Selection Regression of Enrollment and Percent Allocated to Own Growing Season on Treatment

	Dependent variable:	
	Purchased PRF % in Own Growing Season	
	(1)	(2)
Treatment	0.42* (0.24)	0.03 (0.05)
Round	-0.02 (0.04)	-0.02* (0.01)
Risk Aversion	0.05 (0.22)	-0.11** (0.05)
Acres (thousands)	-0.03 (0.26)	
Farm Income	-0.07* (0.04)	
Prop Livestock Income	0.20 (0.18)	
Prop Hay Sold	-0.01 (0.16)	
PRF Prior	1.16*** (0.30)	-0.06* (0.03)
Familiar	0.15 (0.12)	-0.05* (0.02)
Other Crop Insurance: Not Enrolled	0.48* (0.25)	
Other Crop Insurance: Yield or Revenue	0.63** (0.25)	
Other Livestock Insurance	0.27** (0.14)	
Other Livestock Programs	0.15 (0.17)	
Fulltime	0.44*** (0.14)	
Years Farming	0.01** (0.003)	
Maryland	1.14*** (0.31)	
New York	0.49 (0.30)	
Pennsylvania	0.98*** (0.31)	
Education	0.25*** (0.04)	0.01 (0.01)
Treatment x Round	0.02 (0.06)	0.01 (0.01)
Constant	-2.22*** (0.47)	0.65*** (0.07)
Observations		932
Log Likelihood		-521.88
ρ		-0.09 (0.21)
Note:		*p<0.1; **p<0.05; ***p<0.01

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