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Feeder and fed cattle purchases of livestock risk protection

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Abstract

Purpose – Premium subsidy rates were increased in 2019 and 2020 for livestock risk protection (LRP) insurance, which is price insurance for cattle producers. The authors examined if the LRP subsidy rate changes affected the LRP coverage levels purchased by feeder and fed cattle producers.

Design/methodology/approach – The authors collected the United States Department of Agriculture Risk Management Agency summary of business sales data for daily LRP purchases from 2015 to 2023. The authors estimated a multinomial logit model to determine if subsidy rate changes were associated with the likelihood of LRP policies being purchased at different coverage levels.

Findings – After the 2019 and 2020 subsidy rate changes, the likelihood of producers buying LRP-feeder cattle policies with coverage over 95% increased relative to the policies with coverage less than 89.99% but did not influence the likelihood of producers buying LRP-feeder cattle policies with coverage between 90 and 94.99% relative to policies with coverage less than 89.99%. Marginal effects show these subsidy rate changes increased the likelihood of buyers purchasing LRP-feeder cattle policies with greater than 95% coverage. The subsidy change did not affect the purchase of LRP-fed cattle policies.

Originality/value – The results demonstrate the influence of the recent LRP policy adjustments on insurance purchases, which could be important for agency officials and policy makers. This is the first study to explore the LRP policy purchases which provides the United States cattle industry insight into the LRP price insurance take-up, which can guide producer extension education on managing price risk.

Keywords Beef cattle, Insurance, Livestock risk protection, Policy, Risk management

Paper type Research paper

Introduction

Managing various sources of risk, such as drought and price declines, has always been challenging for the United States cattle producers. While they have several options to manage weather risk, such as the livestock forage disaster program and pasture, rangeland and forage (PFR) insurance, livestock risk protection (LRP) insurance, is the only government-sponsored program to help manage economic losses from price declines.

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LRP is a price insurance policy cattle producers can purchase daily to insure a minimum price level for a certain time period. These policies can be customized by the number of head (between 1 and 25,000 head per crop year), the insurance periods (13, 17, 21, 26, 30, 34, 39, 43, 47 or 52 weeks) and coverage levels (70–100%) of an expected price at the end of the insurance period, which varies daily by sex, breed and weight. Purchasers pay a subsidized premium to guarantee a price floor (i.e. coverage price) over an insurance period. LRP policyholders are paid an indemnity payment at the end of an insurance period if the expected price (either Chicago Mercantile Exchange (CME) Feeder Cattle Index or CME live cattle futures price) is lower than the insured coverage price (US Department of Agriculture [USDA] Risk Management Agency [RMA] 2022a).

LRP has been available to producers since 2003, but the number of LRP policies purchased by feeder and fed cattle producers has been low (Hill, 2015; McKendree *et al.*, 2021). Studies often conclude that LRP is prohibitively expensive and depending on the cattle marketing month and market situation, producers are likely better off assuming the risk of a price decline than purchasing LRP policies (Burdine and Halich, 2014; Merritt *et al.*, 2017). The LRP premium subsidy rate was 13% of the total premium cost from 2003 to July 2019, when the subsidy rate was increased to 20% of the total premium cost. Then, in July 2020, the premium subsidy rate was increased again to a tiered rate structure based on the coverage level. The 2020 subsidy rate structure included a 35% subsidy rate for a coverage level between 95% and 100%, 40% subsidy rate for coverage between 90 and 94.99%, 45% subsidy rate for coverage between 85 and 89.99%, 50% subsidy rate for coverage between 80 and 84.99% and 55% subsidy rate for coverage between 70 and 79.99% (USDA RMA, 2022a).

This subsidy rate change increased the probability of LRP paying a greater indemnity than the premium cost (Boyer and Griffith, 2023a; Haviland, 2023) and lowered the premium cost for fed and feeder cattle LRP policies (Boyer and Griffith, 2023b). Boyer and Griffith (2023b) showed the higher the coverage level of LRP, the larger decline in premiums, despite the subsidy rate being lower for the higher coverage level. This is because higher coverage level policies have higher premiums to start with and a 35% subsidy rate for a higher absolute premium resulted in a greater premium cost reduction than a 55% subsidy rate for a lower absolute premium at a lower coverage level. While these studies analyze LRP offering data, they do not analyze the actual purchases of LRP by the producers. Thus, these studies provide no indication if the change in the premium subsidy rate affected LRP purchases. Recently, however, the actual daily purchase data of LRP policies became publicly available (USDA RMA, 2022b), making it possible to partially address some shortcomings of these studies and better understand if the increased subsidy rate has affected the LRP purchases.

There is a large body of literature focused on how premium subsidies impact the enrollment in crop insurance (Goodwin, 1993; Goodwin *et al.*, 2004; Goodwin and Smith, 2013; Yu *et al.*, 2018; Yi *et al.*, 2020). These studies focus on the acre response to subsidy levels or producers' insurance decision at the extensive margin (i.e. insure or not insure). These studies show producers often increase their insured acres with a higher subsidy, which suggests that the LRP purchases could increase with the increased subsidy rate. Extending these models to studying livestock producers' response to the increased LRP subsidy rate at the extensive margin (i.e. additional head or weight to insure) would, however, require strong assumptions. The number of cattle per county that are eligible for LRP changes multiple times within a year and some cattle could be eligible for LRP policies twice in one year. For example, a feeder cattle could have a 13-week LRP coverage policy and have a 13-week fed cattle policy within the same year. Additionally, since LRP policies are offered and sold daily (not annually like crop insurance), the eligible cattle for LRP would need to be identified by county by day to accurately estimate the subsidy rate change on LRP purchases at the extensive margin [1].

There is another strand of literature that focuses on the crop insurance purchasing decisions at the intensive margin or what coverage level or policy type (i.e. revenue protection and yield protection) to purchase (Smith and Baquet, 1996; Richards, 2000; Shaik *et al.*, 2008; Du *et al.*, 2014; O'Donoghue, 2014; Du *et al.*, 2017; Che *et al.*, 2020). Instead of focusing on the quantity of acres insured, the focus of these studies is on the quality of insurance (coverage level and policy type) being purchased. These studies find that crop producers select higher coverage levels (i.e. higher quality) with a higher subsidy rate (Richards, 2000; Du *et al.*, 2014, 2017; Che *et al.*, 2020). These studies also deviate from the extensive margin studies with their modeling approaches by primarily using discrete models such as mixed logit regressions (Du *et al.*, 2017), sample selection models (Smith and Baquet, 1996; Richards, 2000; Du *et al.*, 2014) and multinomial logit regressions (Shaik *et al.*, 2008), which presents results in terms of probability.

The LRP purchase data does allow for an analysis of how the new tiered subsidy rate structure has affected the purchases of various coverage levels of LRP (or at the intensive margin). Such an analysis would make three unique contributions to the literature. First, no one to our knowledge has analyzed the LRP policy purchases, which provides insight into what policy coverage levels and lengths producers are buying. Second, this study builds on a limited literature of livestock producers' participation in government supported programs (Liu *et al.*, 2021). Finally, LRP has recently undergone major changes to the subsidy structure. We can demonstrate producers' purchasing decisions of LRP pre- and post-subsidy rate changes.

The purpose of this study is to analyze the LRP subsidy policy change on the coverage level feeder and fed cattle producers are buying at an intensive margin. We use a novel USDA RMA summary of business sales dataset for LRP that shows the actual daily purchases from 2015 to 2023 (commodity years). Specifically, we estimate a multinomial logit model to determine if the 2019 and 2020 subsidy rate changes affected the likely of a producer buying LRP at different coverage levels. The results are the first to show how feeder and fed cattle producers responded to higher LRP premium subsidies and what LRP policies were purchased. These results are expected to demonstrate the effectiveness of the recent LRP policy adjustments and have implications for further LRP policy improvements.

Data

Daily LRP summary of business data were obtained from USDA RMA (2022b). These data include the sale date, policy commodity, coverage level, insurance period, quantity of head, weight, premiums, subsidies, liabilities, indemnities and other information. We utilize these data for commodity years (July 1-June 30) 2014–2023. Table 1 shows the summary statistics for these data for feeder cattle. Over this period, LRP-feeder cattle policies sold were 36,488, insuring about 5.5 million head of feeder cattle. The average LRP-feeder cattle policy insured about 151 head per policy with an average weight of 123,147 total pounds and an average per head weight of 771 pounds. The average expected ending price was $182 per cwt with a range of $100 to $260 per cwt.

Previous studies have shown that the seasonality of cattle prices can impact the effectiveness of LRP (Merritt *et al.*, 2017; Boyer and Griffith, 2023a; Haviland, 2023). Table 1 shows the months when the LRP policy terminates. More LRP policies for feeder cattle were purchased in March and April than any other month and the fewest were purchased in September and October. These summary statistics could help extension educators better align the LRP purchases with LRP effectiveness. We also included monthly binary indicator

Variable	Average	Standard deviation	Minimum	Maximum
Head	151.381	303.144	1	12,000
Weight per policy (cwt)	1,231.47	2,686.815	4	120,000
Weight per head (cwt)	770.689	127.038	300	1,000
Expected ending price ($/cwt)	181.790	29.835	99.72	259.70
Producer premium ($/cwt)	4.675	1.610	0.15	12.60
January[a]	0.079	0.270	0	1
February[a]	0.092	0.289	0	1
March[a]	0.138	0.345	0	1
April[a]	0.150	0.357	0	1
May[a]	0.068	0.252	0	1
June[a]	0.062	0.241	0	1
July[a]	0.087	0.282	0	1
August[a]	0.076	0.265	0	1
September[a]	0.049	0.217	0	1
October[a]	0.053	0.225	0	1
November[a]	0.072	0.258	0	1
December[a]	0.073	0.261	0	1
2015[b]	0.047	0.212	0	1
2016[b]	0.029	0.167	0	1
2017[b]	0.043	0.202	0	1
2018[b]	0.021	0.144	0	1
2019[b]	0.017	0.129	0	1
2020[b]	0.011	0.105	0	1
2021[b]	0.131	0.337	0	1
2022[b]	0.277	0.448	0	1
2023[b]	0.425	0.494	0	1

Note(s): [a]Month the policy purchased
[b]Commodity year the policy was purchased
Source(s): USDA RMA (2022b)

Table 1. Summary statistics of feeder cattle LRP policies sold from 2014 to 2023 (n = 36,488)

variables equal to one if the LRP policy was purchased during the month. The year dummy variables show that most of the policies were purchased between 2021 and 2023.

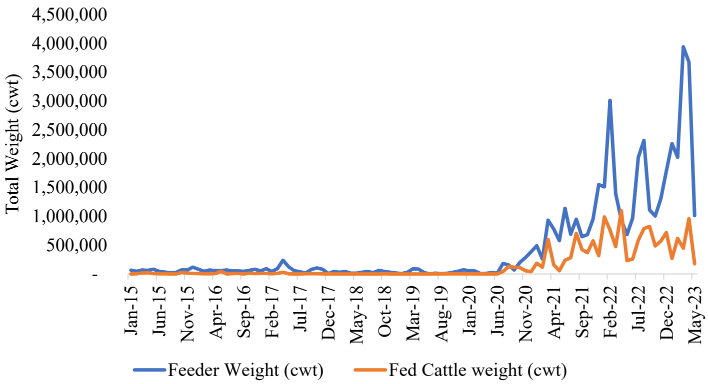
Table 2 displays the same data for fed cattle LRP policies. Over this period, 4,489 LRP-fed cattle policies were sold that insured 1,103,708 head of fed cattle. The average LRP fed cattle policy was larger than feeder cattle, insuring about 246 head per policy with an average total weight of 337,458 pounds, with an average per head weight of 1,366 pounds. The average expected ending price ranged between $100 and $176 per cwt with an average of $145 per cwt. The average fed cattle LRP producer premium was lower than that for feeder cattle, which aligns with what Boyer and Griffith (2023b) reported. More LRP policies for fed cattle were purchased in April and the fewest policies were purchased in June. Like feeder cattle policies, most LRP policies were purchased between 2021 and 2023.

LRP policies are purchased to insure a total weight and the cost is on a per weight basis rather than per head. Figure 1 shows the monthly purchases of feeder and fed cattle LRP policies in weight. The figure displays LRP-feeder cattle policies insured more pounds than LRP-fed cattle policies. The figure also displays that the LRP purchases were low, which is what the literature has indicated (Hill, 2015; McKendree *et al.*, 2021), until around July 2020 when sales of this policy increased. This was when the second subsidy rate increase was established. Tables 1 and 2 show the majority of the LRP purchases occurred after 2021. We provide further discussion on summary statistics in the results section.

Table 2.
Summary statistics of fed cattle LRP policies sold from 2014 to 2023 (n = 4,489)

Variable	Average	Standard deviation	Minimum	Maximum
Head	245.87	489.20	1	8,000
Weight per policy (cwt)	3,374.575	6,860.788	12.5	128,000
Weight per head (cwt)	1,365.63	87.652	1,000	1,600
Expected ending price ($/cwt)	144.55	15.54	100.18	176.36
Producer premium ($/cwt)	3.540	1.133	0.09	8.20
January[a]	0.088	0.284	0	1
February[a]	0.118	0.322	0	1
March[a]	0.115	0.319	0	1
April[a]	0.144	0.351	0	1
May[a]	0.047	0.211	0	1
June[a]	0.030	0.170	0	1
July[a]	0.054	0.225	0	1
August[a]	0.100	0.299	0	1
September[a]	0.078	0.269	0	1
October[a]	0.066	0.248	0	1
November[a]	0.084	0.278	0	1
December[a]	0.077	0.266	0	1
2015[b]	0.014	0.119	0	1
2016[b]	0.013	0.113	0	1
2017[b]	0.016	0.124	0	1
2018[b]	0.006	0.079	0	1
2019[b]	0.003	0.052	0	1
2020[b]	0.004	0.063	0	1
2021[b]	0.112	0.316	0	1
2022[b]	0.427	0.495	0	1
2023[b]	0.404	0.491	0	1

Note(s): [a]Month the policy was purchased
[b]Commodity year the policy was purchased
Source(s): USDA RMA (2022b)



Source(s): USDA RMA (2022b)

Figure 1.
Monthly purchases of LRP fed and feeder cattle LRP policies by total weight (cwt) from 2015 to 2023

Economic and empirical framework

The lack of data on cattle eligible for LRP policies at the county level makes the application of models used to estimate the impacts of crop acres response to subsidy changes (i.e. extensive margin analysis) challenging [2]. However, these data do allow us to apply a limited dependent variable model to analyze if the subsidy rate changes influence the coverage level purchased (i.e. intensive margin). Theoretically, these models assume that the producers select the coverage level to insure their commodity that maximizes their expected utility of their income (Smith and Baquet, 1996; Richards, 2000; Shaik *et al.*, 2008; Du *et al.*, 2014).

Conceptually, an individual's expected utility is conditioned on the individual's risk preferences and evaluation of the risks along with income. Mossin (1968) argues that risk-averse individuals should select full coverage (or the highest coverage level in the LRP case) when insurance premiums are actuarially sound. Boyer and Griffith (2023a) found feeder cattle producers would be better off buying LRP policies with higher coverage levels than lower coverage levels after the 2020 subsidy rate increase, which supports Mossin's (1986) finding when translated to LRP.

We are interested in determining if the higher subsidy rate structure for lower coverage has encouraged producers to purchase lower coverage levels. To model this, we use a multinomial logit model with the dependent variables being binary for the purchase of LRP at a given insurance coverage level. We selected three coverage levels based on the tiered subsidy structure of: (1) 95–100% coverage; (2) 90–94.99% coverage and (3) coverage less than 89.99%. We combined the lower three coverage levels because few policies were purchased under 89.99% coverage (further discussion is provided in the results section). This modeling approach assumes buyers of LRP policies can choose between one of these three coverage levels that maximizes their expected utility and has been used to model crop insurance coverage decisions (Shaik *et al.*, 2008).

We estimate a model for fed cattle LRP policies and a model for feeder cattle LRP policies. The base outcome for each model is the lowest level of coverage (70–89.99% coverage level). The model is described as:

$$\text{Prob}[LRP_{tc} = j|\mathbf{X}_{tc}] = \frac{\exp\ (\mathbf{X}'_{tc}\alpha_j)}{\sum_{j=0}^{2}\exp\ (\mathbf{X}'_{tc}\alpha_j)} \tag{1}$$

where LRP_{tc} is the purchase of a LRP policy on day t and in county c for coverage level j; $j = 0$ when coverage level is less than 89.99%, when 90–94.99% coverage is purchased $j = 1$ and when the 95–100% coverage is purchased $j = 2$; $\mathbf{X}_{tc}$ includes explanatory variables hypothesized to the likelihood of this LRP policy being purchased; α_j a vector of coefficients to be estimated (Greene, 2009). Parameter estimates are interpreted as the probability of purchasing various LRP coverage levels relative to the lowest coverage level (Greene, 2009). These parameter estimates can be difficult to interpret because they are relative to buying the lowest level of LRP coverage (the base outcome). We also estimate marginal effects of a unit change based on the probability of observing the outcome following Greene (2009). The model and marginal effects were estimated using Stata 18.

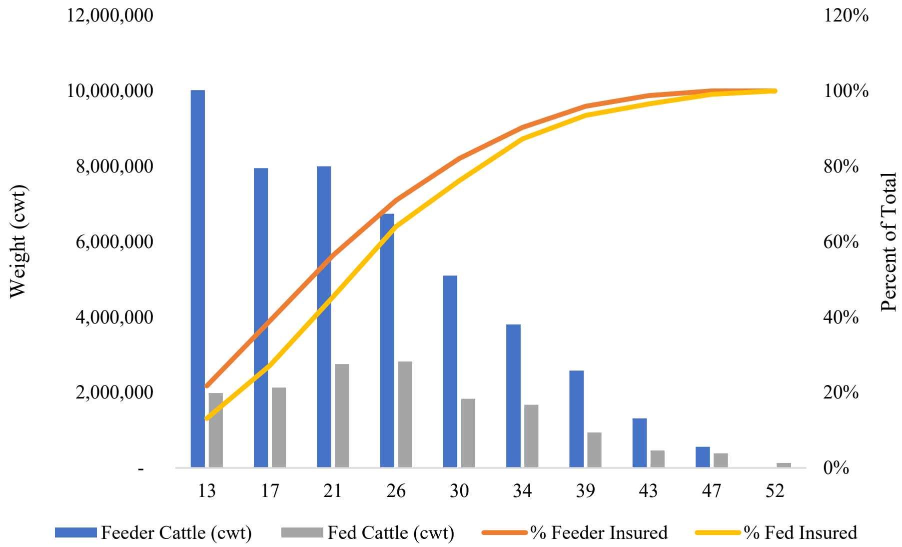
The literature does not provide a solid foundation for specifying this model since no studies have looked at insurance policy purchases for LRP in cattle. Thus, we include explanatory variables to control the policy characteristics, time, space and events of when the subsidy rate was changed. The explanatory variables in these models include expected ending price at the time of the policy being purchased and endorsement length to control for policy characteristics. We also include fixed effects for the month the policy was sold, the state it was purchased in, and year. We include two binary event variables. The 2019 subsidy change variable is equal to one after July 2019, and zero otherwise. The 2020 subsidy change is equal to one after July 2020, and zero otherwise. We did not include the premium paid by the producer since it is a function of the coverage level. An increase in the premium paid by the producer divided by the total liability will increase the likelihood the highest coverage level is purchased since this value is higher with the higher coverage levels. Conversely, a decrease in the premium paid by the producer divided by the total liability will decrease the likelihood the lowest coverage level is purchased since this value is lower with the lower coverage levels.

Results

Summary statistics

It is common for studies to remove LRP-daily offering policies from their analysis with insurance periods exceeding 30 weeks (Burdine and Halich, 2014; Merritt *et al.*, 2017; Boyer and Griffith, 2023a). This is because these offerings are limited and too long for many operators. For example, a 34-week insurance period length is 238 days. This would be a long duration of time for a cattle raiser to own feeder cattle or for a cattle feeder to have cattle on feed. Figure 2 shows the total weight and percent of insured total weight of feeder and fed cattle by insurance period. We see that 86% of all insured feeder cattle were done so with an insurance period of 30 weeks or less. Of the LRP-feeder cattle policies sold, 90% were 34 weeks or less. For fed cattle, we see a similar trend but slightly longer. About 87% of LRP-fed cattle policies were 34 weeks or less and 94% were 39 weeks or less. One explanation for the longer LRP-fed cattle policies is some cattle raisers might retain ownership through finishing, thus, purchasing a fed cattle policy when the cattle were purchased to put on pasture before going to the feedlot. Another possibility is that it would take a feedlot that purchases 400-to-500-pound calves a longer period to finish these animals. Few producers have purchased policies over 39 weeks.

Table 3 shows the total weight and percent of feeder and fed cattle insured across different coverage levels. For feeder cattle, 92% were insured with a coverage level over 95% and 99% were insured with a coverage level greater than 90%. About 92% of fed cattle LRP policies had at least 95% coverage level. Like the insurance periods, studies typically do not consider LRP policies under 85% due to the limited offerings of LRP policies with this coverage level (Merritt *et al.*, 2017; Boyer and Griffith, 2023a). Therefore, we reduced the selection equation to three coverage levels: 95–100% coverage; 90–94.99% coverage and coverage less than



Source(s): USDA RMA (2022b)

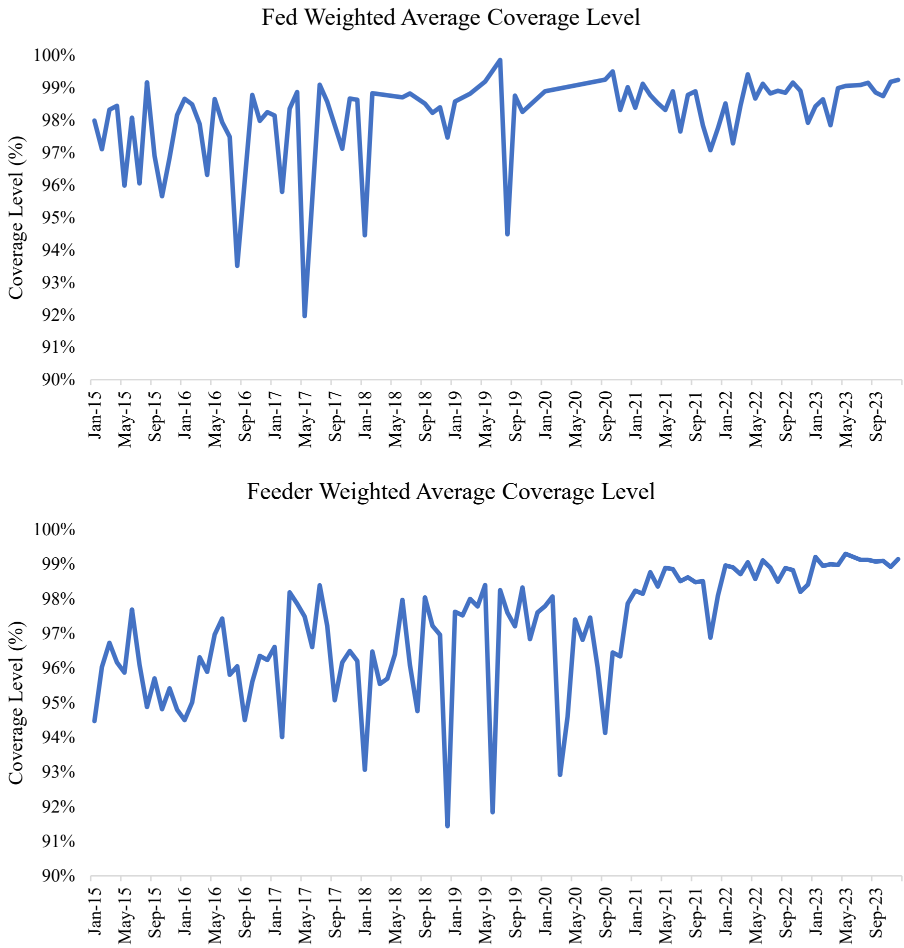
Figure 2.
Total weight (cwt) of feeder and fed cattle insured across insurance periods from 2015 to 2023

89.99%. Figure 3 shows the weighted average coverage level of LRP policies for fed and feeder cattle policies sold each month. Visually, the coverage level for fed cattle appears to be flat over time. However, feeder cattle LRP policy coverage level appears to have increased. The data suggests coverage level selection has increased but the model is needed to test if the coverage level has changed over time.

Table 3. Total weight (cwt) and percent of total weight (cwt) of feeder and fed cattle insured across coverage levels

Coverage level (%)	Feeder cattle (cwt)	Percent of feeder cattle	Fed cattle (cwt)	Percent of fed cattle
75–84.99	4,275	0%	0	0%
80–84.99	20,696	0%	3,306	0%
85–89.99	631,589	1%	94,895	1%
90–94.99	3,152,641	7%	840,103	6%
95–100	42,265,701	92%	14,210,155	94%

Source(s): USDA RMA (2022b)



Source(s): USDA RMA (2022b)

Figure 3. Weighted average coverage level of LRP policies for fed and feeder cattle from 2015 to 2023

Regression

Tables 4 and 5 shows the results for the feeder and fed cattle model, respectively. Various estimated parameters for the month, state and year were significant for both models. These variables are difficult to interpret relative to the dropped variable within the equation and the base outcome; thus, they are not interpreted. For feeder cattle, the natural log of the expected ending price was positive and significant indicating producers were more likely to buy higher coverage level policies when the expected ending price increases. LRP is intended to protect against price declines but when prices increased, the producers were more likely to purchase higher coverage level policy. Perhaps producers believe that when prices increase they can afford to pay a higher premium for LRP insurance.

After the 2019 and 2020 subsidy rate change, the likelihood of producers buying LRP-feeder cattle policies with coverage over 95% increased relative to the policies with coverage less than 89.99%. These subsidy rate changes did not change the likelihood of producers buying LRP-feeder cattle policies with coverage between 90 and 94.99% relative to the low coverage level outcome (coverage less than 89.99%). The lower premium costs shifted buyers of feeder cattle LRP policies to higher coverage level policies. Boyer and Griffith (2023b) showed the greater absolute reduction in premium costs was with the highest coverage level policies, which could explain why more producers shifted to buy higher coverage levels. Another important note is higher coverage level, LRP policies perform better than lower coverage levels (Boyer and Griffith, 2023a); thus, this subsidy rate change has appeared to incentivize producers to the more effective policy options. The results for fed cattle policies showed price and subsidy rate change did not affect purchasing decisions. Figure 1 shows fewer LRP policies are purchased for fed cattle, which might be explained by the other price risk management tools these producers may be more equipped to use (i.e. futures and options contracts).

Table 4.
Estimated parameters of multinomial logit for likelihood of feeder cattle LRP purchases relative to coverage levels less than 89.99% (n = 36,488)

	Coverage 90%–94.99%		Coverage >95%	
Parameters	Parameter estimate	Standard error	Parameter estimate	Standard error
Ln(expected price)	2.495**	0.571	1.993***	0.485
2019 subsidy change	0.260	0.464	1.167***	0.882
2020 subsidy change	0.595	0.457	1.846***	0.776
17-week	−0.006	0.164	−0.163	0.444
21-week	−0.262	0.150	−0.619***	0.852
26-week	−0.663	0.163	−1.049***	0.442
30-week	−0.471	0.194	−0.952***	0.426
34-week	−0.803***	0.217	−1.132***	0.681
39-week	0.089***	0.335	−0.381	0.447
43-week	−0.534	0.378	−1.027**	0.488
47-week	−0.435	0.754	−0.704	0.453
52-week	–		–	
Month fixed effects	Yes[a]		Yes[a]	
Year fixed effects	Yes[a]		Yes[a]	
State fixed effects	Yes[a]		Yes[a]	
Intercept	−10.875***	3.087	−8.191**	2.887
R-squared	0.1343			

Note(s): The base of the model is coverage level policies less than 89.99% and no 52-week policies were sold for feeder cattle
*, **, *** represent significance at the 10%, 5% and 1% levels, respectively
[a]These variables are included in the model but not reported
Source(s): Authors' own work based on data analysis

Parameters	Coverage 90%–94.99% Parameter estimate	Standard error	Coverage >95% Parameter estimate	Standard error
Ln(expected price)	5.240	5.187	2.350	4.871
2019 subsidy change	0.938	1578.947	1.132	1578.947
2020 subsidy change	−14.956	1459.101	−13.739	1459.100
17-week	0.104	0.857	0.017	0.826
21-week	−0.908	0.714	−0.799	0.677
26-week	−0.634	0.703	−0.949	0.672
30-week	−0.580	0.722	−0.981	0.691
34-week	−0.459	0.752	−0.941	0.721
39-week	−1.861**	0.751	−1.929***	0.700
43-week	−2.350**	0.740	−2.880***	0.687
47-week	−1.271	0.870	−1.852***	0.821
52-week	−2.776***	0.990	−2.866***	0.872
Month fixed effects	Yes[a]		Yes[a]	
Year fixed effects	Yes[a]		Yes[a]	
State fixed effects	Yes[a]		Yes[a]	
Intercept	−8.867	603.962	6.709	603.896
R-squared	0.0682			

Note(s): The base of the model is coverage level policies less than 89.99%
*, **, *** represent significance at the 10%, 5% and 1% levels, respectively
[a]These variables are included in the model but not reported
Source(s): Authors' own work based on data analysis

Table 5. Estimated parameters of multinomial logit for likelihood of fed cattle LRP purchases relative to coverage levels less than 89.99% (n = 4,489)

Marginal effects are shown in Table 6, which provide insight into how these variables changed the likelihood of an outcome. A one percent change in the expected ending price when the policy was purchased decreased the likelihood of feeder cattle LRP policies being purchased for under 89.99% coverage level by three percentage points but increased the likelihood policies being purchased with coverage between 90 and 94.99% by about four percentage points. A higher price did not change the likelihood of LRP policies with coverage over 95% being purchased. This result indicates the higher expected ending price encourages producers to buy higher coverage level policies. This further supports the results suggesting that producers might perceive they can afford to pay a higher premium for LRP insurance when prices are higher.

The 2019 and 2020 subsidy rate change decreased the likelihood of buyers purchasing feeder cattle LRP policies at less than 94.99% coverage but increased the likelihood of policies with coverage greater than 95% to be purchased. After 2019, feeder cattle LRP policies with coverage

Subsidy rate change	Coverage <89.99%	Coverage 90%–94.99%	Coverage >95%
Fed cattle			
Ln(expected price)	−0.2906	0.3106	−0.0200
2019 subsidy change	0.0276	−0.0195	−0.0080
2020 subsidy change	0.0425	−0.1437	0.1012
Feeder cattle			
Ln(expected price)	−0.0296***	0.0372**	−0.0075
2019 subsidy change	−0.0150***	−0.0655***	0.0805***
2020 subsidy change	−0.0227***	−0.0837***	0.1064***

Note(s): *, **, *** represent significance at the 10%, 5% and 1% levels, respectively
Source(s): Authors' own work based on data analysis

Table 6. Marginal effects of the subsidy rate change on the LRP policies being purchased

less than 89.99% and between 90 and 94.99% were one and about seven percentage point less likelihood to be purchased, respectively. After 2020, feeder cattle LRP policies with coverage less than 89.99% and between 90 and 94.99% were two and eight percentage point less likelihood to be purchased, respectively. Conversely, feeder cattle LRP policies with coverage levels over 95% were eight percentage points and ten percentage points more likely to be purchased after 2019 and 2020, respectively. Overall, the subsidy rate change appears to have encouraged buyers to purchase higher coverage level for feeder cattle policies, which have historically been more likely to best protect producers against price declines (Boyer and Griffith, 2023a). The subsidy change was found to not impact the purchasing of fed cattle LRP policies.

Conclusion

The USDA RMA increased the LRP feeder and fed cattle premium subsidy reducing the cost of LRP to producers in 2019 and further reducing it in 2020. Research has looked at how this subsidy rate impacted the LRP costs to producers (Boyer and Griffith, 2023a, b) but no study has explored if the higher subsidy (lower premium cost) affected LRP insurance policy purchases. Therefore, we examined how the LRP subsidy change affected the purchases of different LRP coverage levels by feeder and fed cattle producers at an intensive margin. We used the USDA RMA summary of business sales data for daily LRP policies and estimated a multinomial logit model to determine how subsidy rate changes affected the likelihood of producers purchasing LRP policies at different coverage levels.

This study makes several contributions to the literature. It is the first study to explore the LRP purchases. Also, LRP has recently undergone major changes to the subsidy structure. Results demonstrated producers' purchasing the decisions of LRP pre- and post-subsidy rate changes and showed how feeder and fed cattle producers respond to higher LRP premium subsidies and what LRP policies are being purchased. These results demonstrate the effect of the recent LRP policy adjustments on producers' LRP purchases and have implications for further LRP policy improvements.

The regression results showed producers were more likely to buy higher coverage level feeder cattle LRP policies when the expected ending price increases. However, there was no difference in the likelihood of LRP-fed cattle policies across price and subsidy rate changes. The 2019 and 2020 subsidy rate change decreased the likelihood of buyers purchasing feeder cattle LRP policies with less than 94.99% coverage but increased the likelihood of buyers purchasing feeder cattle LRP policies with greater than 95% coverage. In general, the subsidy rate change encouraged buyers of feeder cattle LRP policies to purchase the higher coverage level policies.

This study is not without limitations. We recognize there is a behavioral component to how producers make insurance decisions. Further studies are needed on how choice alternatives, and risk preferences can affect a producer's insurance decision through survey or experimental data. Davidson and Goodrich (2023) recently collected such data to analyze how various factors and information nudges impact producers' purchase of the PRF insurance policy. A study like Davidson and Goodrich (2023) might be warranted for the LRP purchases.

Notes

1. LRP is purchased for a total weight and not by head. To further complicated this type of analysis, we would need daily head and weight eligible for LRP by county. Not only does head change within a county change frequently throughout the year, the weight to insure is also changing.
2. While we cannot test if the subsidy rate changes impacted cattle enrolled in LRP without having the number of eligible cattle data, Figure 1 suggests producers purchased more policies after the 2020 subsidy rate increase. It is worth noting the US cattle herd was declining during this same time (post-2020). It is likely that eligible cattle for LRP declined when LRP sales increased. We present the results for a change in insured weight due to the change in the subsidy level following Yu *et al.* (2018) in the

supplemental information. We recognize the dependent variable is not scaled relative to total eligible cattle, but these results do provide unique insight for cattle price insurance response to subsidy change.

3. We also estimated these models using natural log logarithmic of head insured. The sign and significance of the estimated parameters are the same. The results are robust to total weight or head.

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Appendix
Response to cattle insured with LRP post-subsidy rate change

Estimation

We closely follow the estimation and identification strategy outlined in Yu *et al.* (2018). They theoretically show that the marginal value of enrolling another acre in insurance depends on the subsidy per liability. In our applications, we want to determine how the subsidy per liability impacts additional cattle being insured. We specify a dependent variable of total weight (in pounds) of cattle insured. We choose total weight instead of head since not all cattle are insured at the same weight and the LRP policy insures against the value of the cattle, which includes the number of head and the average weight per animal [3]. The primary explanatory variable is the subsidy per liability, which is dependent on the subsidy rate (i.e. the subsidy divided total premium cost) and becomes a potential source of endogeneity. We also included the expected ending price as an explanatory variable. This is described as

$$\ln(W_{klt}) = \beta_0 + \beta_1 \ln(SL_{klt}) + \beta_2 \ln(EP_{klt}) + \gamma_k + \mu_l + \tau_t + \varepsilon_{klt} \tag{1a}$$

where W_{klt} is the total weight (head times average weight) of cattle insured with an LRP policy in state k ($k = 1, \ldots, K$), month l ($l = 1, \ldots, L$) and year t ($t = 1, \ldots, T$); SL_{ilt} is the subsidy per liability; EP_{ilt} is the expected ending price; β's are parameters to be estimated; γ_k are binary effects attributable to state; μ_l are binary effects attributable to month; τ_t are binary effects attributable to year and ε_{klt} denotes the random error.

We first estimate an ordinary least square model with robust standard errors defined in equation (1a) but also use a two-step GMM estimator. The standard error for this model is a weighting matrix when the error term is heteroskedastic. Like Yu *et al.* (2018), we use an instrument variable for subsidy per liability with the subsidy rate following the GMM estimator approach. This estimation procedure was conducted separately for feeder cattle LRP policies and fed cattle LRP policies. The logarithmic transformation allows estimated parameters to be interpreted as the percent change in total weight insured with LRP with a percent change in the subsidy rate. The C statistic is used to test if the variables are exogenous. The test statistic is a chi-squared with one degree of freedom (~3.84 at the 95% confidence level). If the C statistic is greater than the test statistic, we can reject the null hypothesis that the variables are exogenous; meaning the two-step GMM is the most appropriate estimator.

Results

Table A1 shows the regression results for the feeder and fed cattle using both ordinary least squares regression and the two-step GMM estimator with instrumental variable. We can reject the null hypothesis for the feeder cattle regression that the variables are exogenous, indicating the two-step GMM is the most appropriate estimator. The first stage regression results are shown in the supplemental information. The F-statistic for this model indicates we have a strong instrument, which is what Yu *et al.* (2018) also found for their model. The fed cattle regression, however, fails to reject the null and the ordinary least squares is the most appropriate estimator. We also present the R-squared for these regressions. Therefore, we discuss the ordinary least squares results for the fed cattle and discuss the GMM results for the feeder cattle.

The feeder cattle LRP regression shows the average change in total weight insured is positive and significant when the premium subsidy per dollar of liability increases. A 10% increase in the premium subsidy will encourage around a 0.11% increase in the total feeder cattle weight insured. This was a similar response to what Goodwin *et al.* (2004) and Yu *et al.* (2018) observed for crop acres when the producer paid premium declined. This is also consistent with what Liu *et al.* (2021) found for Chinese herders' responses to higher premiums for livestock insurance. The response to the change in the expected ending price (or short-run own-price elasticity) was negative and significant. This means an increase in the expected ending price, reduces the total weight of feeder cattle insured with LRP. On the contrary, Yu *et al.* (2018) reported high expected prices increase crop acres insured, which matches similar short-run own-price elasticities estimated for crops in the literature (Miao *et al.*, 2016). However, our finding suggests when feeder cattle prices are high, the producers do not see a need to set a price floor with LRP. This was expected since LRP has a history of being expensive and has had limited adoption. Producers purchasing insurance on feeder cattle were more sensitive to changes in expected ending prices than subsidy rate.

The average change in total fed cattle weight insured increased when the premium subsidy per dollar of liability increased. A 10% increase in the premium subsidy will encourage around 0.11% increase in total fed cattle weight insured. This is like the response observed for feeder cattle, suggesting producers in both stages of production have similar own-price subsidy elasticities.

Variable	Feeder cattle: Ordinary least square	Feeder cattle: GMM-instrumental variable	Fed cattle: Ordinary least square	Fed cattle: GMM-instrumental variable
Intercept	14.341*** (0.407)	14.9227*** (0.4122)	22.765*** (2.8697)	21.689*** (2.893)
Ln of subsidy per liability	−0.027 (0.011)	0.1135*** (0.0134)	0.1099*** (0.0316)	0.0723*** (0.0426)
Ln of expected ending price	−1.413*** (0.0735)	−1.426*** (0.074)	−2.960*** (0.565)	−2.904* (0.562)
Year effects	Yes	Yes	Yes	Yes
Month effects	Yes	Yes	Yes	Yes
State effects	Yes	Yes	Yes	Yes
R-squared	0.0964	0.0974	0.1724	0.180
GMM C statistic		127.11		2.107
Observations	36,488	36,488	4,489	4,489

Note(s): *, **, *** represent significance at the 10%, 5% and 1% levels, respectively
Source(s): Authors' own work

Table A1. Estimated parameters for determinants of the total weight of feeder and fed cattle insured with LRP insurance

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