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Enhancing Decision Making in Livestock Risk Protection Insurance: Insights into Optimal LRP Contract Selection

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We identify optimal producer-selected coverage options across all marketing months and insurable commodities within Livestock Risk Protection Insurance. Optimal contracts are defined as those having combinations of coverage length and level that have historically provided the highest probability of a positive net return and the highest average net return. Using probabilistic modeling, we evaluate the effect of producer size on the likelihood of purchasing optimal contracts. Results indicate, 1) optimal contracts generally have relatively higher coverage levels, 2) producers often purchase contracts not identified as optimal, and 3) producers are categorized within two distinct groups when considering optimal contract selection.

Key words: Coverage Length, Coverage Level, Latent Class Analysis

Introduction

Price risk within livestock production significantly impacts producer profitability. As such, producers routinely attempt to mitigate price risk by engaging in risk management practices such as forward contracting, futures hedging, and put options. Each of these practices has demonstrated various levels of effectiveness at reducing price risk (Mark, 2004; Coelho, 2008; Feuz, 2009; Burdine and Halich, 2014; Merrit et al., 2017). In 2003, Livestock Risk Protection (LRP) insurance was introduced as another price risk management tool. Supported by the Risk Management Agency (RMA) of the United States Department of Agriculture (USDA), LRP insurance protects against losses due to negative price fluctuations. LRP insurance, similar to a put option, establishes price floors while allowing producers to benefit from upward price movements in the spot market. Put options cover 50,000 lbs. per contract for feeder cattle. LRP contracts offer flexibility by insuring as few as one animal without the need for margin accounts, making LRP especially beneficial for small-scale producers (Burdine and Halich, 2014; Merritt et al., 2017; Wei, 2019).

Historical LRP participation has been quite low; however, in recent years, participation has increased substantially. In 2005, 2010, 2015, and 2020 the average number of LRP contracts purchased was 1,717 annually; insuring on average 80% feeder cattle, 8.9% fed cattle, and 11.1% swine. In 2021 and 2022 the average number of LRP contracts rose to 8,214 and 15,099 respectively, insuring on average 69.6% feeder cattle, 10.6% fed cattle, and 19.8% swine (USDA, 2023a). The Census of Agriculture, performed every 5 years in the US, records the total number of beef cow operations at 622,162 and hogs and pig operations at 60,809 in 2022. The 2012 Census of Agriculture recorded those same numbers at 727,906 and 63,246 respectively. The percentage

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of contracts purchased relative to the number of operations in 2010 is estimated at 0.18% for cattle (feeder and fed) and 0.26% for swine. By 2022 these values increased to 1.99% for cattle, and 3.87% for swine (USDA NASS, 2024).[1] Therefore, LRP participation rates can be assumed to have been increasing while the total number of operations have been decreasing through time. This increase in LRP participation can be in part attributed to recent changes in the subsidy structure of the program increasing the affordability of LRP insurance relative to other price risk management options (Parsons, 2021; Boyer and Griffith, 2023b). When LRP was first introduced, a flat 13% subsidy was applied towards premiums regardless of the selected coverage level. For the 2019 crop year,[2] the subsidization rate was increased to 20% with additional changes in 2020 culminating in the current variable subsidy rate structure of 35-55% varying inversely with the coverage level (Boyer et al., 2023; Boyer and Griffith, 2023a).

With increasing participation rates in the LRP program, the need for accurate and up-to-date information to aid producers in making informed coverage decisions also increases. Producers consider several factors when purchasing LRP contracts, including desired coverage length and coverage level. Aside from discussions with their insurance agents, it is unclear what information producers currently use to help make coverage choices. Research into optimal coverage strategies with LRP insurance may aid producers in making informed coverage choices together with their insurance agents. This study has three main objectives: 1) determine the historical monthly 'optimal contract options' for feeder cattle, fed cattle, and swine, 2) evaluate the degree to which producers are currently making 'optimal' coverage decisions and 3) evaluate characteristics of producers making 'optimal' coverage decisions. Haviland and Feuz (2022) used the definition of 'optimal' contracts within feeder cattle to include those combinations of coverage length and level that provide the highest average probability of a positive net return (NR) along with the highest average NR. They suggest both the probability of a positive NR as well as the average NR should be considered jointly as they address alternative risk management strategies relevant to producers.

The results deepen the literature by updating and expanding previous work towards identification of optimal LRP contracts for all insurable commodities[3]. They also provide insights for insurance agents, researchers, and Extension educators to assess and enhance the effectiveness of outreach and educational efforts, in providing guidance to producers in their decisions when selecting LRP contract options.

Literature and Background Information

LRP is administered by the RMA and helps to protect producers from negative price risk. Insurable commodities under LRP include feeder cattle, fed cattle, and swine. Within the feeder cattle commodity type, producers may select from steers, heifers, Brahman, and dairy (dairy for beef), each at one of two weight categories: type 1: 0-599 lbs. or type 2: 600-1000 lbs. The RMA offers several contract options daily for each commodity type/subtype. Contracts vary by coverage length, coverage level, expected ending value, and coverage price. Coverage length is the number of weeks from the purchase date that the contract will expire. The coverage level is the percentage of the expected ending value that will be insured as the coverage price. Expected ending values (prices) are not based on individual producers' spot market prices they receive, but instead use indexes based on futures market prices. For feeder cattle, the index used is the Chicago Mercantile Exchange Feeder Cattle Index (CME FCI). Upon contract expiration there are two possible scenarios: 1) prices rose such that the actual ending value is now above the policy coverage price resulting in full premium (less subsidy) paid by the producer with no indemnity received or 2) prices fell such that the ending value is less than the coverage price resulting in the producer

[1] Individual producers may be counted multiple times since data is available for individual contracts purchased which are not combined by producer.
[2] The LRP insurance crop year is from July 1st to June 30th.
[3] We exclude contracts for unborn feeder cattle and unborn swine.

receiving an indemnity payment equal to the difference between the two prices less the subsidy-adjusted producer premium.

Only recently has research been conducted to determine combinations of producer-selected coverage options (length and level) that have historically provided the optimal outcomes for producers. Merrit et al. (2017) conducted a thorough analysis within feeder cattle (weight 2) to determine the combination of coverage length and levels that have historically provided the highest probability of the net price being greater than the CME FCI price. They looked at LRP contracts with ending dates in all 12 months of the year within the 13-, 17-, and 21-week coverage lengths and with coverage levels varying from 85-100%. The authors found several coverage lengths and levels provided similar price protection within each month suggesting that there was no consistent preferred coverage length and level. Their study provided the foundation for examining optimal contract options within LRP insurance and provided producers with valuable information when selecting LRP coverage options at the time.

Boyer and Griffith (2023b) analyzed the effect of the updated subsidy rate structure by comparing the probability of a positive net return pre- and post-subsidy change. They found that assuming premiums were priced consistently pre- and post-subsidy rate change, the new subsidy rate structure lowered the cost of purchasing LRP insurance increasing the probability of a positive net return. Boyer and Griffith (2023a) found the subsidy increases did reduce the cost of LRP policies for feeder and fed cattle LRP policies between $1.41 to $1.90 per cwt and $0.95 to $1.56 per cwt, respectively.

Yu and Gabrielyan (2023) found that in the USDA's Dairy Margin Coverage program, larger farms are more likely to participate and make purchasing decisions that maximize their net returns. The effect of farm size on the purchasing decisions within LRP insurance could likewise be significant. The changes in the LRP subsidy structure necessitate reexamination of the optimal coverage strategies, and expansion of the analysis to include all insurable commodities can fill a gap for producers previously left unserved within the literature. We also note no previous research examining the alignment of actual contracts purchased with those identified as being optimal.

Data and Methods

Data for this research consisted of two parts each retrieved from the USDA, RMA: 1) historical contracts offered daily (USDA RMA, 2023) from 2005 through January 2023 [4] (820,891 observations) and 2) actual producer purchased contracts (USDA, 2023a) from 2005 through January 2023 (60,370 observations). These two data sets each contain contract-specific details, including coverage length, coverage level, premium cost, premium subsidy, expected ending value, coverage price, and actual ending value. Coverage length is measured in weeks including 13, 17, 21, 26, 30, 34, 39, 43, 47, and 52 weeks. The coverage level ranges from 75.00% to 100% of the expected ending value. All prices are expressed as dollars per hundredweight ($/cwt).

Previous literature focused on analysis of optimal coverage contracts for endorsement lengths less than or equal to 21 weeks as there were few observations greater than 21 weeks. We expand the literature by including contracts for 26 and 30 weeks. Figure 1 charts the number of yearly purchased contracts of 26- and 30-week lengths from 2005 to 2022. Post 2020 we note a large increase in purchases of these higher-length contracts, warranting their inclusion in our analysis. Coverage levels below 85.00% are excluded from analysis as they have accounted for less than 1% of the policies historically purchased (USDA, 2023a). Within the analysis, the continuous coverage level variable is split into five different discrete category levels as: 1 = (85.00% - 89.99%), 2 = (90.00% - 92.49%), 3 = (92.50% - 94.99%), 4 = (95.00% - 97.49%), and 5 = (97.50% - 100.00%). A discrete modeling of the coverage level facilitates application of the results for producers when making coverage level selections and aligns with the approach of past literature (Merrit et al., 2017; Haviland and Feuz, 2022; Boyer and Griffith, 2023a and 2023b). The

[4] End date for both data sets is January 23, 2023.

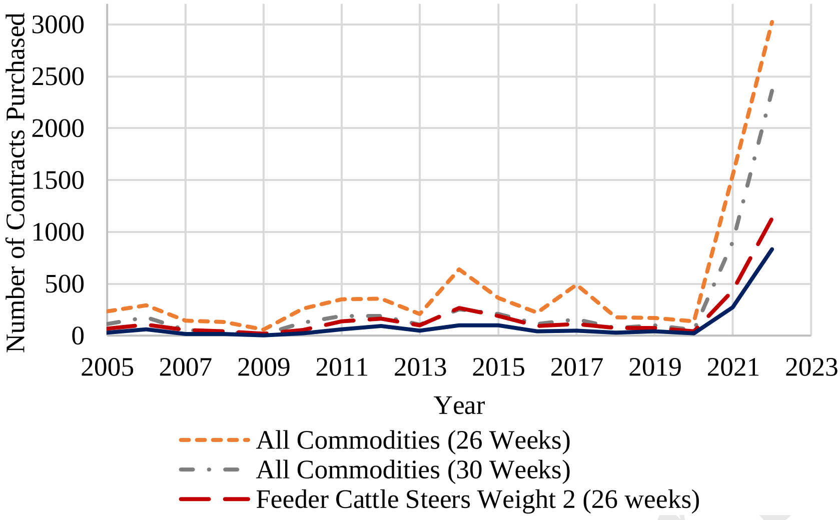

Figure 1. The Number of Purchased Contracts for 26- and 30-Week Contract Lenths Across Years 2005 – 2022 for Feeder Cattle Weight 2 (600-1,000lbs.) and Combined Insurable LRP Commodities

coverage level categories also strategically align with the new subsidy levels to ensure that each discrete category only has one subsidy level assigned to it. The current subsidy rate structure specifies a 45% premium subsidy for coverage levels of 85% to 89.99%, 40% subsidy for levels of 90% to 94.99%, and 35% subsidy for coverage levels above 95% (Parsons, 2021). We apply the most recent subsidy change from 2020 across the entire span of the data holding all else constant. This entails calculating the subsidy for each contract based on the most recent subsidy change and then calculating the producer premium as the total premium less the subsidy amount. This provides a ceteris paribus analysis of the effect of coverage length and level on the average NR and probability of receiving a positive NR. Combining the coverage length and coverage level variables results in 25 independent combinations of variables to be used in the analysis.

Empirical Methods

Using the first dataset (historical contracts) we determine which combinations of coverage length and level provide the highest likelihood of receiving a positive net return. The net return for each contract can be defined as

$$NR_i(\mathrm{L}_i, \mathrm{C}_i) = I_i(\mathrm{L}_i, \mathrm{C}_i) - P_i(\mathrm{L}_i, \mathrm{C}_i) \tag{1}$$

where $NR_i(\mathrm{L}_i, \mathrm{C}_i)$ is the net return ($/cwt) for the ith insurance contract and is a function of coverage length L in weeks, and of coverage level C between 85% - 100%, I_i is the indemnity payment to the producer, and P_i is the producer premium. To ensure we calculate the correct premium paid by the producer we subtract the corresponding subsidy associated with their chosen coverage level. The indemnity amount is defined as

$$I_i(L, C) = \begin{cases} C_i * EP_i(L_i) - AEP_i & if\ C_i * EP_i(L_i) - AEP_i > 0 \\ 0 & if\ C_i * EP_i(L_i) - AEP_i \leq 0 \end{cases} \tag{2}$$

where C_i is the coverage level specified by the ith contract, $EP_i(L_i)$ is the expected price when the insurance policy is purchased, and AEP_i is the actual ending price the day the contract expires.

We create an indicator variable to represent the condition when the net return for a contract is positive, and is expressed as

$$(3) \qquad Q_i^* = \begin{cases} 1 & if\ NR_i(L_i, C_i) > 0 \\ 0 & if\ NR_i(L_i, C_i) \leq 0 \end{cases}$$

where Q_i^*, the indicator variable, equals 1 when the net return for ith contract is positive and equals 0 when the net return is less than or equal to zero. Probit models for each marketing month m and commodity k are then estimated as

$$(4) \qquad \mathrm{P}(Q_i^* = 1)_{k,m,i} = \Phi\langle \alpha_{k,m} + \boldsymbol{\beta}'_{k,m}\mathbf{x}_{\boldsymbol{i}} + u_{k,m,i}\rangle$$

where Φ represents a standard normal cumulative distribution function, $\boldsymbol{\beta}'_{k,m}$ is a vector of coefficients estimated for commodity type k and month m (the month the contract expires, where m = 1, 2, …, 12), **x** is a matrix of discrete indicator variables for the coverage lengths and levels included as both main effects and their interactions, and $u_{k,m,i} \sim N(0, \sigma^2)$, is the error term.

To determine the combinations of coverage length and level for each month that have historically provided the highest average net return we rely on a linear regression specified as

$$(5) \qquad NR_{k,m,i} = \beta_{0,k,m} + \boldsymbol{\beta}'_{k,m}\mathbf{x}_{\boldsymbol{i}} + e_{k,m,i}$$

where $NR_{k,m,i}$ is the net return ($/cwt) for commodity type k where k=1,2,..10, marketing month m where m = 1, 2, …, 12, and the ith daily historical insurance contract, $\boldsymbol{\beta}'_{k,m}$ is a vector of coefficients estimated for commodity type k and month m (the month the contract expires), **x** is a matrix of discrete indicator variables for the coverage lengths and levels and their interactions, and $u_{k,m,i} \sim N(0, \sigma^2)$, is the error term.

To accomplish objective 3, evaluating the characteristics of producers making ‘optimal’ coverage decisions, we explore factors expected to affect the likelihood of producers purchasing optimal contracts. Using the combined results from equations (4) and (5) we identify the optimal contract coverage selections for each marketing month as the joint set of coverage lengths and levels that have statistically provided the highest probability of a positive NR (α=0.05) as well as the highest average NR (α=0.05). Once identified, the optimal coverage selections can be mapped back to the second data set of actual purchased contracts to identify purchases of optimal contracts. An indicator variable Y_i is then created to designate optimally purchased contracts equal to one if the i^{th} purchased contract aligns with an optimal contract and equal to zero otherwise. To model optimal contract selection while allowing for heterogeneity of variable effects, we rely on a latent class logistic regression model. Latent class regression analysis identifies unobserved or latent subgroups in a population that share similar characteristics. Instead of treating all producers purchasing LRP insurance as one homogeneous group, this approach allows for the modeling of distinct segments with unique characteristics. By assigning individuals to these latent classes, researchers can better understand how different factors influence producer selection (Boxall and Adamowicz, 2002; Weller, Bowen, and Faubert, 2020). The equation to estimate the latent class logistic regression of optimal contract selection, uses individual purchased contract data, and is defined as

$$(6) \qquad logit\left(P\left(Y_{c,i} = 1\right)\right) = \beta_{0,c} + \beta_{1,c}NH_i + e_{c,i}$$

where $Y_{c,i}$ is the indicator variable designating an optimal contract selection within latent class c for the ith contract purchased, $\beta_{0,c}$ is the intercept for latent class c, $\beta_{1,c}$ is the coefficient for the effect of number of head NH_i, and $e_{c,i} \sim EV_1(0, \sigma^2)$, i.e. a standard type-1 extreme value distribution, is the error term. In this context, latent class c represents an unobserved subgroup of contract purchases that exhibit similar patterns. The range of c corresponds to the number of latent classes identified in the analysis, c = 1, 2, …, C.

Caution must be used when interpreting the results relative to the number of head insured as one might expect the number of head insured to proxy for size of operation. Yet, research has shown that increasing wealth can lead to Decreasing Absolute Risk Aversion (DARA), suggesting that larger producers may insure fewer animals relative to smaller producers given their levels of risk aversion (Chavas, 2004). This implies limitations to using the number of head as a proxy for size. Yet, the inclusion of the number of head insured within equation (6) allows for evaluation of whether producers insuring more relative to fewer livestock affects the likelihood of purchasing a contract identified as "optimal" within a given marketing month. It may be insightful to include other producer demographics such as age, income, race, gender, etc. as additional explanatory variables[5]. Yet such demographic information is not made publicly available by the RMA. No research has investigated the effect of the number of head insured on the purchasing decisions within LRP. Therefore, despite the limited demographic information available, this analysis and results can provide an informative view on the effect of number of head insured per policy on the likelihood of optimal contract purchasing.

Multinomial logistic (MNL) regression is used to model the likelihood of individuals belonging to the different latent classes (c) in equation (6). The commodity code types—feeder cattle, fed cattle, and swine, are included as explanatory variables within the multinomial logit class prediction model. The latent class model results can aid Extension educators and insurance agents alike in developing a target demographic based commodity type and number of head insured to increase risk management effectiveness for livestock producers.

Results

We begin by looking at the results from feeder cattle weight 2 (600-1,000 lbs.), with discussion of the other commodities following the same empirical strategy and methods. The marginal probabilities are estimated from equation (4) and pairwise comparisons are made for all 25 combinations of coverage length and level as shown in Table 1 for marketing months January-June, and Table 2 for July-December. The results suggest that generally higher coverage levels have historically been more likely to return a positive net return across all marketing months. These results are similar to the findings of Merrit et al. (2017) and Haviland and Feuz (2022). Patterns within coverage length are far less pronounced. The results in Tables 1 and 2 suggest that across all marketing months, the highest probabilities of a positive NR are observed across all analyzed coverage lengths. Yet for individual months we find that there are patterns relating to coverage length. Figure 2 graphs the estimated probabilities of a positive NR by coverage length and level for the marketing months of January and April as well as the annual average. Figure 2 demonstrates a relatively small downward trend for increased coverage length on the probability of a positive net return. This trend is more pronounced in months such as January yet does not hold for others such as April. The effect for coverage length is far less pronounced than the effect of coverage level. The change in the average probability of positive NR across all marketing months from a 13-week contract to a 30-week contract is -0.05%. This is calculated as the average of the difference in the average probability of a positive NR of the 13th and 30th week contracts across all months. The same change from coverage level 1 to coverage level 5 is 28.14%[6]. This implies that producers seeking to maximize the probability of a positive NR when purchasing LRP insurance for feeder cattle (weight 2) should prioritize higher coverage levels while coverage length decisions should primarily depend on market conditions and the producer's marketing window.

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[5] State location was explored as explanatory variables, but results failed to converge. This could be an artifact of having an unbalanced panel of coverage length and level dummies by month. Future research could address this issue.

[6] February and March were not included as there were not enough contracts offered in the 30-week length category, or the first coverage level category (85.00% - 89.99%).

Table 1. LRP Probabilities (%) of a Positive Net Return for Feeder Cattle Steers Weight 2 (600-1,000 lbs.) by Coverage Length and Level for Marketing Months January-June

Coverage Length/Level	January	February	March	April	May	June
Length (weeks)						
13	15.72[b]	--	20.76	27.35[b]	27.16[b]	13.67[b]
17	24.32[a]	16.33[a]	24.30[a]	29.69[a,b]	27.22[b]	15.86[b]
21	24.18[a]	16.38[a]	26.40[a]	32.31[a]	32.66[a]	18.82
26	14.70[b]	13.91[a]	15.35	39.41	34.36[a]	26.95[a]
30	6.88	--	--	30.64[a,b]	35.53[a]	29.68[a]
Level[a]						
1	8.43	--	--	18.79	12.34	5.98
2	15.25	6.71	13.87	28.68	24.43	13.29
3	21.57[a]	13.50	25.18	33.74	33.05	20.22
4	20.34[a]	19.68	36.21	38.73	47.67	34.90
5	31.06	33.77	48.63	45.36	53.51	40.72
Length/Level						
13/1	4.02[j]	--	6.40[j]	15.13[j]	5.72	3.38[m]
13/2	11.91[g,h,i]	5.12[j,i,h]	17.72[i]	22.90[h,i]	19.94[h,i,j]	6.46[l]
13/3	19.24[c,d,e]	13.64[f,e,d]	21.94[h,i]	32.28[e,f,g]	34.15[d,e]	14.05[i,j]
13/4	25.15[b,c]	24.56[c,b]	31.64[e,f]	36.13[d,e,f,g]	51.79[a,b]	33.24[c,d,e]
13/5	34.64[a]	34.92[a]	37.99[d,e]	41.53[b,c,d]	57.70[a]	42.25[b]
17/1	16.39[e,f,g]	2.61[k,j]	5.13[j]	18.35[i,j]	12.60[k]	1.68[m]
17/2	22.15[b,c,d,e]	6.77[g,i,h]	16.84[i]	28.90[f,g,h]	23.59[g,h,i]	10.61[j,k]
17/3	26.26[b]	15.66[f,e,d]	30.95[e,f,g]	36.67[c,d,e,f]	30.13[d,e,f,g]	19.19[g,h,i]
17/4	25.90[b]	32.43[b,a]	39.60[d]	33.18[d,e,f,g]	37.68[c,d]	42.47[b]
17/5	34.66[a]	40.69[a]	47.87[b,c]	39.44[c,d,e]	46.69[b]	50.46[a]
21/1	18.18[d,e,f]	4.58[j,i]	5.39[j]	19.87[i,j]	17.24[j,k]	9.63[k,l]
21/2	21.81[b,c,d,e]	10.73[h,g,f]	19.23[i]	31.16[e,f,g,h]	26.77[f,g,h]	15.77[h,i,j]
21/3	21.89[b,c,d,e]	19.57[d,c]	30.57[e,f,g]	36.68[c,d,e,f]	34.30[d,e,f]	20.61[g,h]
21/4	23.53[b,c,d]	19.39[e,d,c]	41.99[c,d]	37.71[c,d,e,f]	46.50[b,c]	25.66[f,g]
21/5	39.54[a]	33.04[a]	54.77[a,b]	45.50[b,c]	52.23[a,b]	33.46[c,d,e,f]
26/1	8.27[i]	2.72[k,j]	1.71	27.80[g,h]	18.15[i,j,k]	17.11[h,i]
26/2	11.16[g,h,i]	14.20[f,e,d]	7.58[j]	33.06[d,e,f,g]	27.96[e,f,g]	26.32[e,f,g]
26/3	22.57[b,c,d,e]	11.03[g,f]	18.85[i]	31.13[e,f,g,h]	34.96[d,e,f]	28.17[d,e,f]
26/4	11.56[g,h,i]	10.85[h,g,f]	27.14[f,g,h]	57.80[a]	50.33[a,b]	35.23[b,c,d,e]
26/5	25.38[b,c,d]	42.07[a]	51.1[a,b]	58.18[a]	54.76[a,b]	35.80[b,c,d]
30/1	1.08	--	--	17.26[i,j]	18.10[i,j,k]	19.62[g,h,i]
30/2	7.32[i,j]	0.82[k]	5.24[j]	31.86[d,e,f,g,h]	28.86[d,e,f,g]	27.03[d,e,f,g]
30/3	15.54[e,f,g,h]	4.64[j,i,h]	23.17[g,h,i]	29.51[e,f,g,h]	31.95[d,e,f,g]	31.45[c,d,e,f]
30/4	9.09[h,i,j]	6.15[j,i,h,g]	46.85[b,c,d]	36.89[c,d,e,f,g]	57.43[a,b]	41.96[a,b,c]
30/5	11.81[f,g,h,i]	11.68[g,f,e]	62.29[a]	50.38[a,b]	58.20[a]	36.43[b,c,d]

Notes: Data from January 2005- January 24, 2023. Probabilities within a marketing month column sharing a superscript letter are not statistically different at the 5% level.

[a]Coverage levels: 1 = (85.00% - 89.99%), 2 = (90.00% - 92.49%), 3 = (92.50% - 94.99%), 4 = (95.00% - 97.49%), and 5 = (97.50% - 100.00%).

Table 2. LRP Probabilities (%) of a Positive Net Return for Feeder Cattle Steers Weight 2 (600-1,000 lbs.) by Coverage Length and Level for Marketing Months July-December

Coverage Length/Level	July	August	September	October	November	December
Length (weeks)						
13	9.05	5.76	5.66^{b}	15.30^{a}	30.17	18.46^{a}
17	13.13^{b}	8.11^{b}	6.76^{a,b}	12.34^{b}	16.38	20.41^{a}
21	14.01^{b}	11.33^{a}	6.87^{a,b}	13.51^{a,b}	11.91^{a}	9.74
26	19.44^{a}	10.02^{a,b}	8.88^{a}	15.62^{a}	8.60^{b}	5.74^{b}
30	21.76^{a}	11.45^{a}	7.76^{a,b}	11.75^{b}	8.77^{a,b}	3.58^{b}
Level[a]						
1	3.15	2.28	0.78	3.02	4.34	4.80
2	10.53	6.75	4.65	10.49	12.98	10.96
3	16.99	11.8	9.57	16.25	20.52	17.15
4	26.78	16.24	18.83	27.56	25.82	15.99
5	32.00	20.32	25.95	34.62	37.59	24.16
Length/Level						
13/1	1.53^{k}	2.20^{k,l}	0.54^{m}	2.07^{k}	14.84^{g,h,i}	6.93^{e}
13/2	7.07^{h,i}	5.04^{h,i,j}	2.79^{j,k,l}	9.83^{i,j}	20.15^{e,f,g}	18.77^{d}
13/3	11.51^{f,g}	7.39^{g,h}	8.06^{g,h}	18.99^{d,e,f,g}	32.57^{c}	21.73^{c,d}
13/4	17.11^{e}	7.94^{g,h}	18.32^{c,d,e}	32.36^{b}	44.81^{b}	23.67^{c,d}
13/5	25.94^{c,d}	10.69^{e,f,g}	26.50^{a,b}	49.84^{a}	52.72^{a}	32.33^{a,b}
17/1	3.06^{j,k}	1.11^{l}	0.58^{m}	2.70^{k}	3.11^{l,m}	9.72^{e}
17/2	8.62^{g,h,i}	6.79^{g,h}	5.37^{h,i,j}	10.14^{h,i,j}	13.96^{g,h,i}	17.49^{d}
17/3	16.40^{e}	12.98^{d,e,f}	9.09^{f,g,h}	14.1^{g,h,i}	21.13^{d,e,f}	20.07^{c,d}
17/4	25.90^{c,d}	17.88^{b,c,d}	22.67^{b,c,d,e}	25.46^{b,c,d}	23.75^{d,e}	25.70^{b,c}
17/5	30.91^{a,b,c}	18.04^{b,c}	23.27^{b,c,d}	30.04^{b,c}	44.81^{a,b}	39.57^{a}
21/1	2.35^{k}	3.35^{j,k}	0.68^{l,m}	4.02^{k}	1.88^{m}	3.26^{f,g}
21/2	9.31^{g,h}	7.07^{g,h}	3.93^{i,j,k}	16.39^{f,g}	13.04^{h,i,j}	6.37^{e,f}
21/3	16.84^{e}	14.35^{c,d,e}	11.76^{f,g}	13.87^{g,h,i}	17.45^{e,f,g,h,i}	19.22^{c,d}
21/4	30.63^{a,b,c}	22.62^{a,b}	20.77^{b,c,d,e}	24.37^{c,d,e}	18.24^{e,f,g,h}	9.36^{e}
21/5	37.18^{a}	23.18^{a,b}	23.83^{a,b,c,d}	22.89^{c,d,e,f}	28.95^{c,d}	20.72^{c,d}
26/1	8.07^{g,h,i}	3.68^{i,j,k}	1.41^{k,l,m}	4.00^{k}	2.07^{m}	1.45^{g}
26/2	16.73^{e,f}	6.59^{g,h,i}	11.63^{f,g}	9.95^{h,i,j}	7.80^{j,k,l}	5.43^{e,f,g}
26/3	19.81^{d,e}	10.50^{e,f,g}	10.29^{f,g,h}	18.22^{e,f,g}	12.93^{g,h,i,j}	9.88^{e}
26/4	31.43^{a,b,c}	14.08^{c,d,e,f}	14.89^{e,f}	28.13^{b,c}	13.21^{f,g,h,i,j}	9.30^{e}
26/5	33.47^{a,b}	27.36^{a}	26.03^{a,b,c}	42.35^{a}	18.35^{e,f,g,h,i}	9.16^{e}
30/1	5.30^{i,j}	1.98^{k,l}	1.59^{k,l,m}	3.41^{k}	1.89^{m}	1.61^{g}
30/2	19.59^{d,e}	9.09^{f,g}	3.64^{j,k,l}	5.47^{j,k}	4.96^{k,l,m}	2.35^{f,g}
30/3	29.28^{b,c}	15.48^{c,d,e}	9.60^{f,g,h,i}	17.01^{e,f,g,h}	10.09^{i,j,k}	6.19^{e,f,g}
30/4	38.73^{a}	22.73^{a,b}	15.70^{d,e,f}	26.77^{b,c,d,e}	19.61^{d,e,f,g,h,i}	4.76^{e,f,g}
30/5	36.05^{a,b}	27.27^{a}	33.59^{a}	25.00^{b,c,d,e,f}	26.13^{c,d,e}	5.49^{e,f,g}

Notes: Data from January 2005- January 24, 2023. Probabilities within a marketing month column sharing a superscript letter are not statistically different at the 5% level.

[a]Coverage levels: 1 = (85.00% - 89.99%), 2 = (90.00% - 92.49%), 3 = (92.50% - 94.99%), 4 = (95.00% - 97.49%), and 5 = (97.50% - 100.00%).

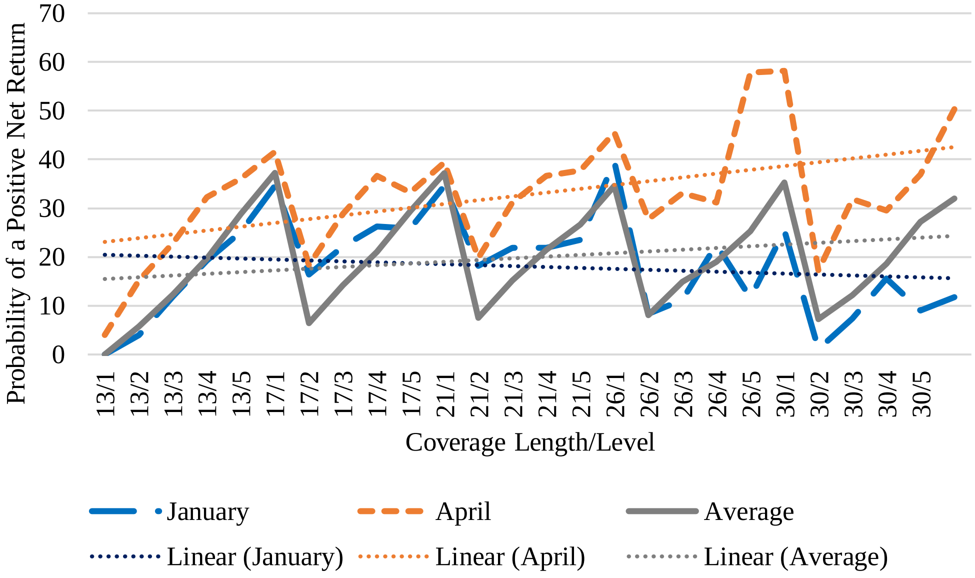

Figure 2. The Probability of a Positive Net Return by Coverage Length and level for Marketing Months January, April, and Averaged Across All Marketing Months for Feeder Cattle Weight 2 (600-1,000lbs.)

The results across all combinations of coverage length and level display few contracts with probabilities of a positive net return greater than 50%. This suggests that in general, LRP feeder cattle contracts are not expected to provide a positive NR. This finding aligns with the RMA's reported average loss ratio and premium adjusted loss ratio from 2005 through 2023 of 0.84 and 1.00 respectively (USDA, 2023b). With a premium adjusted loss ratio of 1.00, for every dollar of producer-premium, one dollar is returned to the producer on average in indemnification (i.e., NR=0).

After estimation of equation (5), a pairwise comparison of marginal effects of coverage length and level is made to identify the contract options which have historically provided the statistically highest (α=0.05) average net return for each marketing month. The results are shown in Table 3 for the marketing months January-June, and Table 4 for the months July-December. The implications from the results for the average NR model are similar to those of the probability of a positive NR. Increasing the coverage level has a positive effect on the NR on average across all marketing months while the effect of coverage length varies across months.

By analyzing the results from Tables 1-4, we can identify the joint set of contract options that have historically provided the highest probability of a positive NR and highest average NR. We present this updated consolidated set of optimal contracts for feeder cattle weight 2 for each month in Table 5. The optimal contract options for each marketing month are shaded in grey within Table 5. This set of optimal contracts can aid livestock producers in making informed coverage decisions when making LRP insurance purchases. As an example of how the information in Table 5 could be used, assume a producer typically markets feeder cattle in April. This producer, referencing Table 5, would purchase a contract for 26 weeks in October with a coverage level of a 4 or 5 (95.00-100.00%). Of course, having been identified as historically optimal does not guarantee similar future performance. However, as producers make LRP coverage selections, this historically optimal set would provide some objective ranking information based on historical performance to guide producers in their selection process. To evaluate our second objective of assessing whether producers' current purchasing patterns align with this optimal choice set, we

Table 3. LRP Average Net Returns for Feeder Cattle Steers Weight 2 (600-1,000 lbs.) by Coverage Length and Level for Marketing Months January-June

Coverage Length/Level	January	February	March	April	May	June
Length (weeks)						
13	0.09^{b}	-0.07^{a}	0.40^{a}	2.04^{a}	1.03	0.17^{c}
17	0.27^{a,b}	-0.20^{a}	0.46^{a}	2.09^{a}	1.42^{a}	0.30^{c}
21	0.54^{a}	-0.54	0.62^{a}	2.14^{a}	1.61^{a}	0.39^{b,c}
26	-0.55	-1.11	-0.42^{b}	2.80	1.61^{a}	0.91^{a}
30	-1.27	-1.93	-0.22^{b}	0.73	1.48^{a}	0.66^{a,b}
Level^{a}						
1	-0.31^{b}	-0.65^{a}	-0.55^{a}	0.84^{b}	-0.06	-0.33
2	-0.15^{b}	-0.81^{a}	-0.52^{a}	1.40^{a,b}	0.40	-0.18
3	0.28^{a}	-0.66^{a}	-0.03	1.95^{a}	1.10	0.23
4	-0.32^{b}	-0.85^{a}	0.64	2.75	2.82	1.15
5	0.43^{a}	-0.05	1.85	3.71	3.56	1.66
Length/Level						
13/1	-0.37^{f,g,h,i}	-0.49^{d,e,f}	-0.12^{g,h,i,j}	1.06^{i,j}	-0.28^{j}	-0.23^{i,j}
13/2	-0.20^{d,e,f,g,h}	-0.58^{e,f,g}	0.00^{g,h,i,j}	1.54^{f,g,h,i,j}	-0.04^{i,j}	-0.32^{j}
13/3	0.05^{c,d,e,f,g}	-0.22^{c,d,e}	0.33^{f,g}	2.13^{d,e,f,g,h}	0.63^{h,i}	-0.12^{h,i,j}
13/4	0.18^{b,c,d,e,f}	0.08^{b,c}	0.78^{e,f}	2.81^{c,d,e}	2.17^{e,f}	0.62^{e,f,g}
13/5	0.88^{a}	0.92^{a}	1.14^{d,e}	3.18^{b,c,d}	3.47^{b,c}	1.21^{b,c,d,e}
17/1	-0.17^{d,e,f,g,h}	-0.50^{d,e,f,g}	-0.50^{i,j,k,l}	1.18^{h,i,j}	0.21^{h,i,j}	-0.45^{j}
17/2	0.23^{a,b,c,d,e,f}	-0.70^{e,f,g}	-0.44^{i,j,k,l}	1.56^{f,g,h,i,j}	0.67^{h,i}	-0.56^{j}
17/3	0.50^{a,b,c,d}	-0.23^{b,c,d,e}	0.26^{f,g,h}	2.54^{c,d,e,f}	1.53^{f,g}	-0.16^{h,i,j}
17/4	0.06^{b,c,d,e,f,g}	0.09^{b,c,d}	1.12^{d,e}	2.43^{d,e,f,g}	2.36^{d,e}	1.19^{b,c,d,e}
17/5	0.77^{a,b}	0.40^{a,b}	2.14^{a,b}	3.13^{b,c,d}	2.94^{c,d,e}	2.03^{a}
21/1	-0.01^{c,d,e,f,g}	-0.53^{d,e,f,g}	-0.54^{i,j,k,l}	0.97^{i,j}	0.12^{h,i,j}	-0.24^{j}
21/2	0.46^{a,b,c,d,e}	-0.73^{e,f,g}	-0.35^{h,i,j,k}	1.68^{e,f,g,h,i,j}	0.70^{g,h,i}	-0.14^{h,i,j}
21/3	0.71^{a,b,c}	-0.58^{e,f,g}	0.39^{f,g}	2.03^{d,e,f,g,h,i}	1.51^{f,g}	0.36^{f,g,h,i}
21/4	-0.09^{c,d,e,f,g,h}	-1.12^{g,h}	1.35^{c,d,e}	2.91^{c,d,e}	3.18^{b,c,d}	0.86^{d,e,f}
21/5	1.69^{a}	0.19^{b,c}	2.59^{a}	3.75^{b,c}	3.43^{b,c}	1.48^{a,b,c,d}
26/1	-0.32^{e,f,g,h,i}	-0.97^{f,g,h}	-0.84^{k,l}	0.92^{i,j}	-0.07^{i,j}	-0.24^{i,j}
26/2	-0.69^{g,h,i,j}	-0.80^{e,f,g}	-1.10^{l}	1.49^{e,f,g,h,i,j}	0.65^{g,h,i}	0.50^{e,f,g,h}
26/3	0.54^{a,b,c,d}	-1.00^{f,g,h}	-0.93^{k,l}	1.98^{d,e,f,g,h,i}	0.93^{g,h}	0.98^{c,d,e,f}
26/4	-1.45^{j}	-2.12^{i,j}	-0.69^{j,k,l}	4.65^{a,b}	3.15^{b,c,d,e}	1.85^{a,b}
26/5	-1.09^{i,j}	-0.77^{e,f,g}	1.58^{b,c,d}	6.16^{a}	4.46^{a}	2.07^{a}
30/1	-1.12^{i,j}	-1.12^{f,g,h}	-1.14^{l}	-0.49^{k}	-0.42^{j}	-0.57^{j}
30/2	-1.38^{j}	-1.62^{h,i}	-1.15^{l}	0.30^{j,k}	0.02^{h,i,j}	0.01^{g,h,i,j}
30/3	-0.93^{h,i,j}	-2.12^{i,j}	-0.72^{j,k,l}	0.34^{j,k}	0.79^{g,h,i}	0.75^{d,e,f,g}
30/4	-1.27^{i,j}	-2.57^{j}	0.21^{f,g,h,i}	1.06^{g,h,i,j}	4.22^{a,b}	2.06^{a,b}
30/5	-1.72^{j}	-2.41^{i,j}	1.98^{a,b,c}	3.22^{b,c,d}	4.06^{a,b}	1.76^{a,b,c}

Notes: Data from January 2005- January 24, 2023. Average Net Returns within a marketing month column sharing a superscript letter are not statistically different at the 5% level.
[a]Coverage levels: 1 = (85.00% - 89.99%), 2 = (90.00% - 92.49%), 3 = (92.50% - 94.99%), 4 = (95.00% - 97.49%), and 5 = (97.50% - 100.00%).

Table 4. LRP Average Net Returns for Feeder Cattle Steers Weight 2 (600-1,000 lbs.) by Coverage Length and Level for Marketing Months July-December

Coverage Length/Level	July	August	September	October	November	December
Length (weeks)						
13	-0.35[b]	-0.82[b,c]	-0.56[a]	0.28[a]	1.01	0.24[a,b]
17	-0.14[a,b]	-0.75[a,b]	-0.72[a,b]	0.08[a,b]	0.05	0.49[a]
21	0.03[a]	-0.54[a]	-0.88[b]	-0.17[b,c]	-0.32	-0.18[b]
26	-0.01[a]	-0.72[a,b]	-0.71[a,b]	-0.47[c]	-1.28[a]	-1.04
30	-0.21[a,b]	-1.05[c]	-1.29	-0.39[c]	-1.72[a]	-2.18
Level[a]						
1	-0.54[c]	-0.68[a]	-0.76[a,b]	-0.61[a]	-0.54[b]	-0.35[b,c]
2	-0.53[b,c]	-0.80[a]	-0.91[b]	-0.45[a]	-0.40[a,b]	-0.44[c]
3	-0.28[b]	-0.69[a]	-0.91[b]	-0.41[a]	-0.12[a]	0.06[a,b]
4	0.31[a]	-0.85[a]	-0.81[a,b]	0.39	-0.11[a]	-0.22[a,b,c]
5	0.51[a]	-0.84[a]	-0.50[a]	1.12	0.75	0.14[a]
Length/Level						
13/1	-0.44[e,f]	-0.44[a,b,c]	-0.47[a]	-0.34[e,f,g,h,i]	0.08[c,d,e]	-0.22[b,c,d,e,f,g]
13/2	-0.43[e,f]	-0.51[a,b,c,d,e]	-0.66[a,b,c]	-0.35[e,f,g,h,i]	0.30[b,c,d]	0.04[a,b,c,d,e,f]
13/3	-0.38[e,f]	-0.47[a,b,c]	-0.55[a,b,c]	0.04[d,e,f,g,h]	1.14[a]	0.54[a,b]
13/4	-0.26[d,e]	-1.07[f,g]	-0.56[a,b,c]	0.59[c,d]	1.35[a]	0.19[a,b,c,d,e]
13/5	-0.20[d,e]	-1.84	-0.62[a,b,c]	1.89[a]	2.55[a]	0.75[a]
17/1	-0.50[e,f]	-0.65[b,c,d,e,f]	-0.71[a,b,c]	-0.59[g,h,i]	-0.40[d,e,f,g]	-0.27[b,c,d,e,f,g]
17/2	-0.53[e,f]	-0.77[c,d,e,f,g]	-0.83[a,b,c,d,e]	-0.24[e,f,g,h,i]	-0.32[d,e,f,g]	0.28[a,b,c,d]
17/3	-0.34[e,f]	-0.68[b,c,d,e,f]	-0.79[a,b,c,d,e]	-0.58[g,h,i]	0.13[c,d,e]	0.44[a,b,c]
17/4	0.37[b,c]	-0.72[b,c,d,e,f]	-0.45[a,b]	0.88[b,c]	0.05[c,d,e,f]	0.39[a,b,c]
17/5	0.48[b,c]	-0.97[d,e,f,g]	-0.78[a,b,c,d,e]	1.40[a,b]	0.96[a,b]	1.83[a]
21/1	-0.47[e,f]	-0.66[b,c,d,e,f]	-0.91[a,b,c,d,e]	-0.68[h,i]	-0.78[g,h,i,j]	-0.04[a,b,c,d,e,f]
21/2	-0.58[e,f]	-0.76[c,d,e,f,g]	-1.09[b,c,d,e]	-0.13[d,e,f,g,h,i]	-0.33[d,e,f,g]	-0.66[d,e,f,g,h]
21/3	-0.31[e,f]	-0.51[a,b,c,d]	-1.05[b,c,d,e]	-0.42[f,g,h,i]	-0.60[e,f,g,h,i]	0.66[a,b]
21/4	0.57[b]	-0.27[a,b]	-0.53[a,b,c]	0.45[c,d,e]	-0.39[d,e,f,g,h]	-0.52[c,d,e,f,g,h]
21/5	1.23[a]	-0.45[a,b,c]	-0.71[a,b,c,d]	0.19[c,d,e,f,g]	0.69[a,b,c]	-0.49[c,d,e,f,g,h]
26/1	-0.59[e,f]	-0.70[b,c,d,e,f]	-0.94[a,b,c,d,e]	-0.94[i]	-1.02[g,h,i,j,k]	-0.81[e,f,g,h,i]
26/2	-0.43[e,f]	-0.85[c,d,e,f,g]	-0.8[a,b,c,d,e]	-1.01[i]	-1.13[g,h,i,j,k]	-1.38[g,h,i,j]
26/3	-0.09[c,d,e]	-0.81[c,d,e,f,g]	-0.97[a,b,c,d,e]	-0.82[i]	-0.83[f,g,h,i,j,k]	-1.04[f,g,h,i]
26/4	0.53[b,c]	-1.18[g]	-1.23[c,d,e,f]	-0.34[e,f,g,h,i]	-1.86[k,l]	-0.55[b,c,d,e,f,g]
26/5	0.75[a,b]	-0.03[a]	0.65[a]	1.15[a,b,c]	-1.71[j,k,l]	-1.45[h,i,j,k]
30/1	-0.86[f]	-0.98[e,f,g]	-0.95[a,b,c,d,e]	-0.68[g,h,i]	-1.51[i,j,k,l]	-1.15[f,g,h,i,j]
30/2	-0.75[e,f]	-1.18[g]	-1.41[d,e,f]	-0.95[i]	-1.70[j,k,l]	-2.24[i,j,k]
30/3	-0.15[c,d,e]	-1.07[f,g]	-1.51[e,f]	-0.43[e,f,g,h,i]	-2.27[l]	-2.55[j,k]
30/4	0.56[a,b,c]	-1.11[f,g]	-1.87[f]	-0.15[d,e,f,g,h,i]	-1.69[j,k,l]	-2.28[i,j,k]
30/5	0.40[b,c,d]	-0.93[c,d,e,f,g]	-0.79[a,b,c,d,e]	0.46[b,c,d,e,f]	-1.45[h,i,j,k,l]	-2.95[k]

Notes: Data from January 2005- January 24, 2023. Average Net Returns within a marketing month column sharing a superscript letter are not statistically different at the 5% level.
[a]Coverage levels: 1 = (85.00% - 89.99%), 2 = (90.00% - 92.49%), 3 = (92.50% - 94.99%), 4 = (95.00% - 97.49%), and 5 = (97.50% - 100.00%).

include within Table 5 the actual number of polices purchased in every month for each combination of coverage length and level. It is evident that, in general, producers are choosing policies with higher coverage levels. Patterns within the selection of coverage length are less pronounced and demonstrate that producers may not be as informed concerning selection of coverage lengths to mitigate risk and maximize returns. Within feeder cattle steers (weight 2), optimal contracts were purchased 31.91% of the time (7,592 of the total 23,792 contracts purchased between 2005 and January 2023).

Other Feeder Cattle Commodities

We find that across all feeder cattle types (steers, heifers, Brahman, dairy), and weight categories (weight 1 and weight 2), the optimal choice set identified is identical to the steers feeder cattle weight 2 optimal set with only a few exceptions within dairy feeders. These exceptions are due to a minority of dairy feeder contracts not consistently being scaled by the RMA feeder cattle price adjustment factor for dairy feeders over the period of our data. After accounting for those discrepancies, the optimal choice set aligns with the choice sets for the other feeder cattle commodity types. Consistent optimal choice sets across feeder cattle types are expected as the prices follow the CME Feeder Cattle futures market and are then cash settled to the CME FCI and adjusted using price adjustment factors (USDA RMA, 2022). The number of actual contract purchases for feeder cattle types other than steers and heifers are quite limited. For this reason, we forgo an analysis of purchase patterns relative to the optimal choice set identified for Brahman and dairy feeder cattle. Individual results analyzing the probability of a positive NR, and the highest average NR are likewise consistent across these commodities.

Fed Cattle

We follow the same analysis method to identify the optimal contract options for fed cattle as for feeders. We focus here on the identification of patterns within the optimal choice set identified. Individual results of equations (4) and (5) are provided in the online supplement (www.jareonline.org) as Tables S1, S2, S3, and S4. The number of actual LRP fed cattle policies purchased (2005 through January 2023) by coverage length and level is represented in Table 6 with the optimal set of coverage lengths and levels highlighted in grey. This table depicts valuable patterns for producers choosing to purchase a LRP fed cattle policy. The highest density of optimal contracts occurs from September to December. While fed cattle in the U.S. are generally marketed throughout the year, seasonality does play a role with late spring and early fall typically exhibiting higher numbers. The pattern identified in feeder cattle of optimal contracts being found in the higher coverage levels is also apparent in fed cattle. Only two optimal contracts were identified below the 95% coverage level. Of the 31 contracts identified as optimal, 24 were in coverage lengths of 21 weeks or less, with 16 of them at 17 weeks or less. When comparing actual fed cattle LRP purchases with the optimal choice set identified, we find a smaller percentage of optimal purchases compared to feeder cattle. Of the 5,484 contracts purchased, only 1,156 (21.08%) aligned with the optimal set. The majority of policies purchased are for marketing months in the spring and early summer months, with the maximum number of policies being purchased in April (706), and the least in November (287). However, April only has two optimal contracts, while November has six. With fed cattle being marketed throughout the year, producers could benefit by purchasing those contracts in their marketing month that are included within the optimal choice set.

Table 5. Number of LRP Feeder Cattle Steers Weight 2 (600-1,000 lbs.) Insurance Contracts Purchased by Month from January 2005 through January 24, 2023: Values Shaded in Gray Indicate the Combinations of Coverage Length and Level that have Historically Provided the Highest Probability of a Positive Net Return and the Highest Average Net Return

Coverage Length/ Level[a]	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Grand Total
13/1	25	25	20	22	14	14	12	13	18	8	9	11	191
13/2	31	48	55	18	37	17	11	23	23	22	19	14	318
13/3	170	128	164	115	74	60	37	63	61	51	47	55	1025
13/4	78	73	117	89	55	46	44	58	66	49	77	50	802
13/5	**501**	**440**	**593**	**374**	**360**	**241**	**206**	**335**	**334**	**422**	**453**	**296**	4555
17/1	10	15	33	10	12	6	9	21	13	12	9	4	154
17/2	29	27	58	21	32	25	25	38	25	23	20	12	335
17/3	83	66	158	58	69	47	27	77	47	34	40	39	745
17/4	71	56	113	47	54	28	41	89	45	44	41	42	671
17/5	**421**	**207**	**533**	**282**	**317**	**177**	**212**	**416**	**243**	**261**	**379**	**245**	3693
21/1	14	11	24	28	25	20	12	34	28	12	7	5	220
21/2	24	22	42	20	29	20	18	49	30	27	20	17	318
21/3	68	44	99	83	57	30	47	84	65	58	38	30	703
21/4	70	44	82	61	48	37	47	76	61	80	46	25	677
21/5	**402**	**150**	**301**	**258**	**305**	**196**	**181**	**473**	**277**	**231**	**334**	**203**	3311
26/1	8	7	10	8	25	12	21	31	19	15	6	8	170
26/2	30	11	16	16	38	14	23	53	23	23	8	5	260
26/3	28	10	42	23	46	26	28	62	57	56	33	23	434
26/4	41	14	50	16	36	22	24	74	48	38	28	18	409
26/5	**281**	**163**	**204**	**148**	**195**	**133**	**172**	**408**	**276**	**248**	**130**	**111**	2469
30/1	8	3	8	6	16	6	7	21	9	8	8	2	102
30/2	7	4	8	4	15	9	6	31	14	8	15	2	123
30/3	21	17	13	12	28	8	15	52	15	27	10	7	225
30/4	18	10	22	5	7	10	14	62	24	19	20	8	219
30/5	**154**	**108**	**183**	**71**	**126**	**71**	**77**	**309**	**204**	**157**	**162**	**41**	1663
Grand Total	2593	1703	2948	1795	2020	1275	1316	2952	2025	1933	1959	1273	23792

[a]Coverage length/levels: defined as the length in weeks and the levels coded as 1 = (85.00% - 89.99%), 2 = (90.00% - 92.49%), 3 = (92.50% - 94.99%), 4 = (95.00% - 97.49%), and 5 = (97.50% - 100.00%).

Table 6. Number of LRP Fed Cattle Insurance Contracts Purchased by Month from January 2005 through January 24, 2023: Values Shaded in Gray Indicate the Combinations of Coverage Length and Level that have Historically Provided the Highest Probability of a Positive Net Return and the Highest Average Net Return

Coverage Length/Level[a]	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Grand Total
13/1	2	5	2	4	10	2		1	2	1	1	1	31
13/2	2	7	5	10	5	6	1	2	1	2	1	3	45
13/3	12	14	14	22	28	18	5	7	7	6	9	5	147
13/4	5	9	16	14	12	6	8	3	3	3	9	7	95
13/5	**50**	**49**	**39**	**75**	**106**	**63**	**53**	**25**	**22**	**47**	**47**	**69**	645
17/1	2	1	6	3	5	4	2	3	2		2		30
17/2	5	6	3	2	10	8		2	2	3	8	3	52
17/3	5	12	12	29	21	22	17	7	3	7	3	4	142
17/4	4	10	7	15	15	18	6	8	5	3	3	14	108
17/5	**48**	**66**	**49**	**89**	**71**	**60**	**51**	**63**	**15**	**43**	**35**	**90**	680
21/1	3	2	5	6	4	7	7	3	5	2	1	3	48
21/2	4	7	9	7	5	9	4	3	3	4	3	3	61
21/3	18	12	10	21	20	18	21	12	7	6	9	5	159
21/4	16	11	10	20	13	13	18	10	7	6	5	8	137
21/5	**68**	**78**	**64**	**116**	**92**	**76**	**88**	**61**	**66**	**29**	**34**	**72**	844
26/1	4	6	3	7	8	5	5	4	3	7	3	2	57
26/2	2	3	2	7	7	3	10	9	7	7	4	3	64
26/3	4	11	11	12	18	16	16	18	16	11	4	7	144
26/4	6	20	9	25	15	11	9	13	6	11	5	7	137
26/5	**53**	**116**	**76**	**107**	**92**	**65**	**67**	**66**	**54**	**76**	**38**	**59**	869
30/1	1	7	3	6	4	3	4	6	7	6	10	3	60
30/2	3	3	4	2	8	7	5	3	6	6	4	2	53
30/3	3	6	12	13	13	8	12	9	10	15	9	8	118
30/4	1	7	10	7	7	2	11	4	8	12	7	5	81
30/5	**30**	**59**	**76**	**97**	**48**	**64**	**45**	**72**	**41**	**75**	**33**	**37**	677
Grand Total	351	527	457	716	637	514	465	414	308	388	287	420	5484

[a]Coverage length/levels: defined as the length in weeks and the levels coded as 1 = (85.00% - 89.99%), 2 = (90.00% - 92.49%), 3 = (92.50% - 94.99%), 4 = (95.00% - 97.49%), and 5 = (97.50% - 100.00%).

Swine

For swine we evaluate contracts ranging from 13 to 26 weeks rather than up to 30 weeks as in the cattle commodities. The shorter biological growth cycle within swine relative to cattle decreases the number of contracts offered and purchased at higher coverage lengths. Similar to Fed Cattle, results from equations (4) and (5) are provided in the online supplement as Tables S5, S6, S7, and S8. The consolidated optimal choice set overlaid with the actual contracts purchased from 2005 to January 24, 2023, is shown in Table 7. The results display an expanded optimal choice set for swine relative to feeder and fed cattle. The average number of optimal choices within a month for Swine is 5.6, while for feeder and fed cattle it is 2.5 and 2.6 respectively. Similar to feeder and fed cattle, swine producers are choosing higher coverage levels on average. While most of the optimal contracts were in the higher coverage levels of 4 and 5 (95.00-100.00%), there were seven that occurred at the coverage level of 3 (92.50 – 94.99%) and three that occurred at a level of 2 (90.00 – 92.49%). This suggests that relative to feeder and fed cattle, the effect of coverage level on the optimal contracts identified is less pronounced within swine. This could indicate increased price volatility in the swine market relative to the feeder and fed cattle markets such that policies with lower coverage levels within swine have frequently triggered indemnity payments. Because LRP premiums are positively related to coverage levels, there is a tradeoff when evaluating coverage level and expected net return. While contracts with lower coverage levels would be expected to be indemnified less frequently, the lower premium levels associated with these contracts may result in a point of indifference when considering average NR and the probability of a positive NR. In evaluating coverage length, we found that most marketing months have optimal contracts in each of the different lengths. Notable exceptions include May, June, and July in which only the longer lengths of 21 and 26 weeks had optimal contracts. In total there were 6,804 contracts purchased and 3,761 of those represented contracts in the optimal choice set or 55.28%. The overall expanded optimal choice set within swine helps explain this increased percentage of optimal contracts purchased relative to feeder and fed cattle.

Latent Class Optimal Contract Selection Model

Due to the unobservable nature of the classes, determining the appropriate number of existing classes is challenging. Various techniques have been developed for choosing the appropriate number of classes. One commonly employed approach involves the minimization of information criterion such as the Bayesian Information Criterion (BIC) or Akaike information criterion (AIC) over multiple classes (Alvarez, del Corral, and Tauer, 2012; Yin et al., 2024). After estimating equation (6) we find two distinct latent classes or groups within our dataset. We find that, based on the minimization of both the BIC and AIC the model estimated with two latent classes would be preferred to the model with only one class. AIC values were 75,881.85 and 75,601.61 for the single and 2-class model respectively and BIC values were 75,899.87 and 75,664.67 for the single and 2-class model respectively. Models with higher orders of latent classes were explored but failed to converge with class specified greater than 2. The results of both the multinomial logit class prediction model as well as the individual logistic regression models for classes 1 and 2 are summarized in Table 8. The class prediction model results, appearing in the upper portion of Table 8, suggest that fed cattle and swine producers are relatively more likely than feeder cattle producers to belong to class 2 with both exhibiting positive coefficients significant at the 1% level. Thus, fed cattle and swine producers would be expected to be relatively less likely to select optimal LRP contracts relative to feeder cattle producers. As feeder cattle producers represent the base or reference category, we find they are more likely to fit within class 1. Examining the latent class logit model results (lower portion of Table 8) we find that the number of livestock insured has a positive effect on the likelihood of purchasing an optimal contract within the first class. The

Table 7. Number of LRP Swine Insurance Contracts Purchased by Month from January 2005 through January 24, 2023: Values Shaded in Gray Indicate the Combinations of Coverage Length and Level that have Historically Provided the Highest Probability of a Positive Net Return and the Highest Average Net Return

Coverage Length/Level[a]	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Grand Total
13/1	11	4	8	7	17	21	12	8	3	2	11	12	116
13/2	13	9	13	8	17	9	15	6	12	12	13	10	137
13/3	16	15	19	20	29	35	19	18	19	17	22	26	255
13/4	15	7	11	10	14	9	4	6	4	20	9	24	133
13/5	**93**	**77**	**60**	**86**	**65**	**99**	**34**	**74**	**72**	**118**	**55**	**110**	943
17/1	13	14	15	11	8	22	15	6	2	3	8	13	130
17/2	12	11	9	10	9	14	8	9	5	9	10	19	125
17/3	18	20	19	22	20	43	22	13	10	17	13	17	234
17/4	10	17	8	9	9	17	9	5	4	7	11	7	113
17/5	**67**	**115**	**64**	**76**	**78**	**81**	**109**	**52**	**53**	**120**	**60**	**125**	1000
21/1	8	13	16	14	7	19	18	28	5	7	4	12	151
21/2	11	7	7	11	6	9	11	4	1	7	9	6	89
21/3	21	21	13	16	19	21	25	25	11	24	19	21	236
21/4	17	13	8	4	2	7	13	10	3	14	9	23	123
21/5	**131**	**137**	**65**	**123**	**63**	**68**	**98**	**90**	**39**	**124**	**60**	**227**	1225
26/1	11	16	15	14	11	12	10	14	10	1	4	5	123
26/2	11	8	11	10	8	1	8	3	5	5	3	4	77
26/3	25	16	10	12	19	24	18	21	7	21	11	27	211
26/4	15	11	7	22	2	5	5	8	2	2	4	17	100
26/5	**135**	**138**	**74**	**116**	**63**	**118**	**106**	**107**	**64**	**69**	**51**	**242**	1283
Grand Total	653	669	452	601	466	634	559	507	331	599	386	947	6804

[a]Coverage length/levels: defined as the length in weeks and the levels coded as 1 = (85.00% - 89.99%), 2 = (90.00% - 92.49%), 3 = (92.50% - 94.99%), 4 = (95.00% - 97.49%), and 5 = (97.50% - 100.00%).

Table 8. Latent Class Results Likelihood of Selection of Optimal Contracts

	Multinomial Logit Class Prediction Model					
	Coefficient		Standard Error			
Class 1	(base outcome)					
Class 2						
Commodity Type						
Fed Cattle	0.255	***	0.038			
Swine	0.657	***	0.050			
Constant	0.175	**	0.074			
	Latent Class Logistic Regression Results					
	Class 1			**Class 2**		
	Odds Ratio[a]		**Standard Error**	**Odds Ratio[a]**		**Standard Error**
Number of Head (1000s)	5.346	***	1.458	1.050		0.040
Constant	2.242	***	0.262	0.004	*	0.012
Marginal Means	0.749		0.025	0.004		0.012
Class Membership Probability		**43%**			**57%**	

Notes: *, **, *** indicate statistical significance at the 10%, 5%, and 1% level
Data included in model ranged from 2005 to January 24, 2023
Number of observations = 60,370
[a]Odds ratio quantifies the likelihood of an event occurring relative to the likelihood of it not occurring calculated as e^β

estimated odds ratio of 5.3 for number of head (1000s) in the first class suggests that for every additional 1,000 head of livestock insured, producers within the first class are 5.3 times more likely to purchase an optimal contract. Within the second class we do not find enough evidence to suggest that the number of head has a significant effect on the likelihood of purchasing an optimal policy. The probabilities of belonging to either class suggest that the majority (57%) of livestock producers would fit within the second class with the minority in the first class (43%). We also calculate the marginal means for Class 1 and Class 2 with the results included in Table 8. Those within class 1 are much more effective at choosing optimal contracts with a marginal mean of 0.75, while the greater portion of the population assumed to belong to class 2 rarely purchase an optimal LRP policy with a marginal mean of 0.0044. One plausible explanation for this finding may coincide with the importance of coverage level on the optimal contract identification. The data for the actual purchased contracts (Tables 5-7) displays many contracts purchased at low coverage levels that often would not be included in the optimal set. Producers purchasing such low levels of coverage may think of their policy as providing catastrophic coverage for when prices experience unexpected sharp declines. Yet, this study demonstrates that positive correlation between coverage level and the probability of a positive NR as well as average NR. This would imply that producers investing in this “catastrophic” type coverage would be better suited to purchase contracts with higher coverage levels and should be one of the primary targets of educational outreach efforts.

Conclusion and Implications

This study makes significant contributions to aid producers in making informed LRP coverage decisions and Extension and insurance agents in directing educational efforts surrounding LRP insurance. We provide a consolidated choice set of historically optimal LRP contracts for feeder cattle, fed cattle, and swine. Second, we evaluate if producers have historically been purchasing these optimal contracts with mixed results across commodity types. The percentages of optimal contracts selected for feeder cattle, fed cattle, and swine are approximately 32%, 21%, and 55% respectively. Finally, our latent class analysis identifies two distinct classes among livestock producers based on their likelihood of selecting optimal contracts. A minority of producers (43%) are routinely selecting optimal contracts, and the likelihood of optimal contract selection is shown to be significantly influenced by the number of head insured. This same minority is also more likely to be feeder cattle producers rather than fed cattle or swine producers. A majority (57%) of producers, however, are not selecting optimal contracts and their likelihood of optimal contract selection is not shown to be influenced by size. This majority is more likely to be swine and fed cattle producers versus feeder cattle producers.

This study can greatly benefit producers using LRP insurance enabling them to make informed coverage selections that coincide with coverage selections that have historically provided optimal outcomes. When producers meet with their insurance agent to make policy coverage decisions these results can provide some objective historical information to aid in the decision-making process. We find that producers would benefit from choosing higher coverage levels on average. LRP is a price risk management tool and is not designed towards long-run returns above costs, but it is designed to insure against negative price movement to decrease a producer risk exposure. Our results can provide objective information when making coverage selections but are not intended to replace consultation with an approved insurance agent. Additionally, LRP coverage selections should always be made after careful consideration of current market expectations and in consideration of a producer's marketing objectives. Producers may consider their current marketing timeline and objectives with the optimal contracts identified being used as a guide in making coverage selections.

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