Agricultural and Resource Economics Review (2025), 1–21
doi:10.1017/age.2025.10

RESEARCH ARTICLE

Optimal contract design under asymmetric information to incentivize preconditioning calves for feedlots

Leslie J. Verteramo Chiu[1,2], Loren W. Tauer[2] and Yrjo T. Grohn[1]

[1]Department of Population Medicine and Diagnostic Sciences, Cornell University, Ithaca, NY, USA and [2]Applied Economics and Management, Cornell University, Ithaca, NY, USA
Corresponding author: Leslie J. Verteramo Chiu; Email: ljv9@cornell.edu

(Received 17 April 2024; revised 11 November 2024; accepted 4 December 2024)

Abstract

We analyze the equilibrium conditions in which contracts are desirable for firms (buyers) with various levels of management efficiencies procuring a factor input under two levels of quality from supplies. The quality of the factor input, which affects production efficiency, may be known to the buyer; the efficiency of the firm is not known to the supplier. We estimate, using principal-agent models, that firms with high-management efficiency do not have the incentive to pay a quality premium to suppliers, but firms operating with low management efficiency are willing to offer a price premium for quality. The model is applied to the question of preconditioning cattle for the feedlot.

Keywords: Feedlots; information asymmetry; preconditioning; principal-agent; optimal contracts

Introduction

Contractual relationships between producers and processors are becoming more common in modern food value chains in developed and developing countries (Otsuka et al., 2016; Meemken and Bellemare, 2020; Barrett et al., 2022). Contractual relationships decrease the risk of supply shortages, price, and quality uncertainty. Studies that found welfare improvement in participating farmers include Barrett et al. (2012), where they studied the experiences of five African countries, and Michelson (2013) on coffee farmers in Nicaragua. Contractual relationships, however, do not always translate into welfare improvement for producers (Bellemare and Bloem, 2018; Meemken and Bellemare, 2020). Uneven relationships between producers and processors, or traders, can increase transaction costs, especially under value chain heterogeneity (Pingali et al., 2007; Wang et al., 2014).

Heterogeneity in value chains affects the supply and demand dynamics for inputs of various qualities. Firms producing heterogeneous output quality may select inputs of various quality levels (Curzi et al., 2015), and their choice of input quality depends, among others, on the firm's technology and efficiency (Gaigné and Gouel, 2022). A firm's

https://doi.org/10.1017/age.2025.10

marginal return to quality depends on its value chain and technology. Input quality assurance is central in value chains that pay a quality premium.

Consequently, the objective of this paper is to develop an empirical model of a food value chain where there are processors operating with heterogeneous managerial efficiency and input suppliers that produce under different quality levels, and design optimal contracts based on those scenarios. The empirical model in this paper is constructed on the US beef value chain.

Beef industry structure in the US

The U.S. beef production system involves multiple heterogeneous stakeholders scattered around the country although concentrated in few states. The top 10 calf-producing states comprise 54% of total national production (USDA:NASS, 2021). The beef production cycle begins with cow-calf operators and typically ends at feedlots where cattle are fattened to a desired weight before slaughter. The beef system can involve many paths and actors from production to feedlot[1]. Cow-calf operators represent a heterogeneous group in the U.S. beef production system. About 37% of all beef cow inventory in the U.S. is in operations with fewer than 100 cows (USDA:NASS, 2017). This fragmentation in cattle production is reflected in the diverse genetic quality of the calves produced. The genetic quality and health of the calves produced are major determinants in the performance of the animal in the feedlot, as measured by average daily gain (ADG), morbidity, and mortality rate (DeLong et al., 2023). While some aspects of the calf quality may be observed, such as body condition and symptoms of diseases, quality of genetics and health condition may not be evident to the calf buyer. This information asymmetry can be reduced by quality certifications of calves. In the beef industry, a common certification scheme is obtained by following a preconditioning and health protocol after weaning.

The practice of preconditioning cattle involves following a vaccination protocol to protect against Bovine Respiratory Disease (BRD), parasites and other pathogens, and adjusting the diet and feeding conditions. Common protocols require 45 days of preconditioning prior to sale (Avent et al., 2007; Lalman and Ward, 2005). Preconditioning is a management practice with the objective to improve the animal's immune system and reduce stress for newly incoming cattle to a feedlot, thus reducing disease incidence. The level of stress of incoming cattle to feedlots, due to an abrupt change in the cattle's environment and diet, can be substantial to make them more susceptible to diseases, particularly BRD (Galyean et al., 2022). Feedlot operators can also incur extra costs introducing animals to the feedlot that are more susceptible to BRD since it can lead to a spread of the disease among cattle. BRD is the most common disease in feedlots and its treatment and prevention requires the use of antimicrobials, which adds to the expenses of feedlot operators (USDA: NAHMS, 2013) but can have negative public health implications via antibiotic resistance.

Preconditioned cattle have been estimated to have lower morbidity and mortality at the feedlot compared to non-preconditioned cattle (Earley et al., 2017; Griebel et al., 2014). These benefits translate into lower use of antimicrobials and lower costs to the feedlot. The benefits of preconditioning to the beef system have been studied under various situations (Dhuyvetter, 2004; Cravey, 1996).

[1]https://www.ers.usda.gov/topics/animal-products/cattle-beef/sector-at-a-glance/

Although preconditioned cattle add value to the beef system and command a higher price than non-preconditioned animals[2] (Garber et al., 2022; Verteramo Chiu et al., 2022; Zimmermann et al., 2012), the practice of preconditioning has not been widely adopted. The benefits of preconditioning, and thus the incentives to precondition, differ by local conditions, and manager's characteristics (Schulz et al., 2015). Hilton (2015) reported that the percentage of calves sold through Superior Livestock[3] video auctions that were weaned certified was 27%. The lack of adoption might be explained by information asymmetries between producers and buyers of preconditioned cattle, and by the difference in feedlot performance, of preconditioned and non-preconditioned cattle. Information asymmetries in cattle transactions have been reported by Williams et al. (2012), Zimmerman (2010), and Chymis et al. (2007), among others. Producers have information on the genetics quality and health history of the cattle, but that information is not known or easily observed by the buyer. DeLong et al. (2023) estimated the willingness to pay cow-calf operators at $21/ head for a genomic test that helps them market their cattle. Some feedlots may be reluctant to purchase preconditioned cattle due to their higher costs and the variability of benefits. The perceived benefits may not outweigh the costs. On the other hand, non-preconditioned cattle under the right conditions may perform well enough to become attractive to some feedlots. Differences in management skills and infrastructure among feedlots affect the profitability of incoming cattle despite the preconditioning status of the animal. The low uptake of preconditioning cattle can lead to missing opportunities for reducing antimicrobial use.

The use of preconditioning certification schemes[4] decreases the information asymmetry problem (Williams et al., 2012; Bulut and Lawrence, 2007; Chymis et al., 2007) allowing for a better distribution of profits; however, that decrease in information asymmetry may not be sufficient to make preconditioning a profitable strategy for cattle producers. The preconditioning premium does not always translate into higher profits received by producers of preconditioned cattle (Thrift and Thrift, 2011). Preconditioning may not be a sustainable practice if producers cannot get a share of the preconditioning benefits of the system that covers their costs and incentivize the continuity of the practice. Contracts that decrease information asymmetries and incentivize the production of high-quality cattle can be developed using principal-agent (PA) models.

Principal-agent models for agriculture have been analyzed under various contexts in the beef industry. Impact of cattle performance incentives using PA models has been studied by King et al., (2007) and Starbird (2005), among others. Resende-Filho and Buhr (2008) estimated the benefit of a cattle traceability system to monitor injection-site lesions in beef. Feedlot contracts have been analyzed using ADG as a key profitability indicator (Maples et al., 2022; Thompson et al., 2014). The use of genotypic information in feedlot contracts is found to be prohibitive if performed on all cattle, although random sampling has been suggested (Thompson et al., 2014). Other indicators of feedlot performance used to price cattle under performance contracts include marbling (DeVuyst et al., 2011) and tenderness. Weaber and Lusk, 2010) and Tang et al. (2017) look at the effect of animal characteristics and placement decisions in retaining ownership at the feedlot. Although

[2]Preconditioned cattle under the OQBN protocol, for instance, received an average premium of $11.93/ cwt in 2019 (latest reported values) (OQBN, 2019).

[3]http://www.superiorlivestock.com/

[4]There are various preconditioning certification programs in the U.S., for instance OQBN-VAC 45 of Oklahoma State University, VAC-45 of Texas A&M University, and VAC-45 of Superior Livestock Auction. All require the same vaccinations.

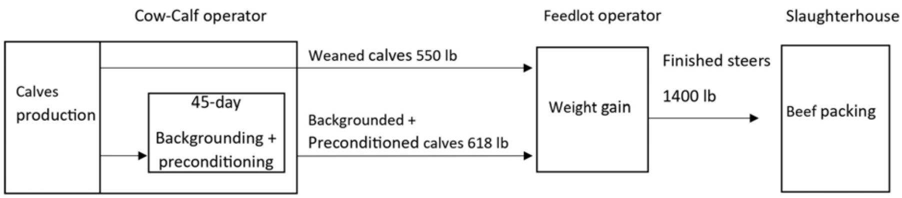

Figure 1. Beef production system described in this study consisting of a cow-calf operator with backgrounding capacity, feedlot, and slaughterhouse.

retaining ownership increases risk to the cow-calf operators, it has been found to increase profit most of the time (Lawrence, 2005; Fausti et al., 2003).

This paper analyzes the scenarios in which preconditioned cattle are desirable to feedlots and develops contractual arrangements between cattle producers and feedlots that incentivize preconditioning through sharing of the net benefits at the feedlot. We divided feedlots into three levels of management quality: low, medium, and high, based on a net return percentile distribution. These contractual arrangements could lead to an equilibrium where preconditioning becomes the dominant strategy for cow-calf operators. This analysis assumes that only the distribution of net returns of preconditioned and non-preconditioned cattle are known by the feedlot, rather than a certain estimate. These contracts focus on net returns of cattle at the feedlot.

We look at different price scenarios and risk preferences of producers and estimate how these differences affect optimal contract specification. We found that a single contract can incentivize preconditioned cattle producers while disincentivizing non-preconditioned cattle producers from introducing their cattle into feedlots. When we account for differences in feedlot management quality, which ultimately impact net returns per animal, we found that high-quality management feedlots may not be willing to pay a premium for preconditioned cattle, unlike low-quality management feedlots, which obtain the most benefit from purchasing preconditioned cattle.

The rest of the paper is organized as follows. The model section is presented next, where we describe a segment of the beef production system of the U.S. and the data used in the development of the optimal contracts, the assumptions of the two entities of the system, and the model used in the analysis, next we present the results and discussion section, and finally the conclusion.

Model

Beef production system

We focus on a specific subset of the beef production system in the U.S. which includes two relevant entities: a cow-calf operator and a feedlot. This system of production represents a scenario where cow-calf operators, with background capacity, sell directly to a feedlot. Although this system reflects a specific path among many possible paths in the beef production system in the U.S., it simplifies the analysis. We based our production system from that described in Verteramo Chiu et al. (2022), shown in Figure 1. We focus on the cow-calf operator delivering a newly weaned calf to a feedlot and comparing it with performing a 45-day post-weaned backgrounding process with a preconditioning protocol prior to feedlot delivery.

Feedlot contract design

We look at different risk preferences of producers and feedlot management levels and demonstrate how these different scenarios affect the equilibrium contract terms between feedlots and calf producers. The contracts between an agent (calf producer) and a principal (feedlot) were designed using a principal-agent model. In a principal-agent model, the principal offers a contract to the agent that maximizes the principal's profit subject to participation and an incentive compatibility constraint for the agent. The participation constraint is the minimum amount that makes the agent willing to participate in the contract. This is the opportunity cost of the agent. In this analysis, the participation constraint is what the producer can receive with certainty for his cattle or the market price of the cattle. The incentive compatibility constraint is the condition in which the agent's payoff is determined, partially at least, by the performance of his work. This constraint must ensure the complete process of preconditioning. Certification schemes ensure compliance with a preconditioning protocol providing assurance to the feedlot and fulfilling the compatibility constraint. Although certification fraud may be possible, it is unlikely that a cow-calf operator planning to continue doing business with the feedlot would falsify the certification for a long time before being detected at the feedlot and face reputation loss, since the effectiveness of preconditioning on cattle performance at feedlot is well studied. Later we discuss the implications of this constraint not being fulfilled.

In this analysis, net returns and payoffs per unit of finished cattle are determined by the cattle performance at the feedlot, so a key element in the analysis is the stochastic performance of preconditioned and non-preconditioned cattle in the feedlot. For simplicity, our analysis estimates the net returns for an individual animal, but the analysis can be extended for a group of animals. The net returns to the feedlot, under a contract that pays a share of the net returns to the producer and a fixed amount for an animal is

$$\pi_k = \alpha_k\left[P_k - FC_k\left(\widetilde{\theta_k}, \bar{x}\right)\right]/(1 - ir)^{DF_k/365} - \beta_k \tag{1}$$

and the return to the cow-calf operator is

$$w_k = (1 - \alpha_k)\left[P_k - FC_k\left(\widetilde{\theta_k}, \bar{x}\right)\right]/(1 - ir)^{DF_k/365} + \beta_k \tag{2}$$

The net return of the cow-calf operator is estimated after subtracting production costs $C_k(x)$ from w_k. Where $\alpha \in [0, 1]$ is the share of the net return of the finished cattle received by the feedlot, similarly, $1 - \alpha$ in equation (1) is the share to the cow-calf operator of the net returns to the feedlot of the finished animal. The subscript k represents the animal type, preconditioned or non-preconditioned, denoted p and np, respectively. The variable payment is assumed to be received once the animal is finished, which depends on the number of days in feedlot (DF_k), discounted at interest rate ir. P_k is the revenue of a finished animal (per head) which may or may not differ between preconditioned and non-preconditioned animals, $FC_k\left(\widetilde{\theta_k}, \bar{x}\right)$ is the cost function of a finished animal of type k in the feedlot, which depends on random vector $\widetilde{\theta_k}$ of performance parameters, and vector $\bar{x}$ of non-random input prices, such as feed and treatment prices. The parameters in $\widetilde{\theta_k}$ incorporates ADG, days on feed, interest rate, mortality rate, and sick rate. β is a fixed amount paid to the cow-calf operators. The net return to the cow-calf operator, equation (2), depends on the type of cattle produced, k. The distribution of the stochastic term $FC_k\left(\widetilde{\theta_k}, \bar{x}\right)$ depends on the distribution of $\widetilde{\theta_k}$. We assume that the feedlot operator is risk-neutral since they can spread the risk among many lots of cattle. The agent is assumed to have a Constant Absolute Risk Aversion utility over return w, $U(w_k) = 1 - e^{(-w_k r)}$, with a constant absolute risk aversion coefficient r. The certainty equivalent (CE), or the amount

https://doi.org/10.1017/age.2025.10

of money willing to receive for certain that produces the same utility as a lottery, $U(CE) = E(U)$, which provides a money metric for selecting stochastic outcomes, is $CE_k(w_k) = -\ln[-E(U(w_k))]/r$.

The problem to solve is of the following form.

$$Max_{\alpha,\beta} \sum_{k\in(p,np)} \pi_k = \left(\alpha\left[P_k - FC_k\left(\widetilde{\theta_k}, \bar{x}\right)\right] - \beta_k\right) \tag{3}$$

$$Subject\ to\ \ CE_k(w_k) = -\ln[E(U(w_k))]/r \geq \overline{C_k} \tag{4}$$

The principal maximizes its net revenue, equation (3), which is a sum of the net revenues of the animal entering the feedlot, by offering a contract to the agent with parameters α^* and β^*. $\overline{C_k}$ in equation (4) is the participation constraint of the agent that produces cattle of type k. The monetary value of the agent from participating in this contract should be at least $\overline{C_k}$, which is the expected net return from selling weaned calves in the market that covers the cost of production, and in the case of preconditioned cattle production, the cost of preconditioning. The cost of production depends on fixed parameters and does not have implied variance. We assume that the payment to the cow-calf operators is realized at the time of sale of the finished animal.

The solution to the maximization problem is a contract that the feedlot offers to the producer based on the preconditioning status of the animal. The contract parameterization depends, among other things, on the cattle performance at the feedlot that is attributable to feedlot management. The optimal contracts are estimated by simulating the net returns over the parameter domain.

Data

Model parameterization

All parameterization of the system described in Figure 1 was obtained from Verteramo Chiu et al. (2022). The performance at the feedlot is determined by the preconditioning status of the calf.

The preconditioning protocol assumed in this model follows a 45-day program similar to the VAC-45 from Superior Livestock Auction. Preconditioned cattle are dehorned, castrated, vaccinated, and dewormed.

The costs of producing a calf are estimated from Kansas State University (KSU) KFMA Enterprise Reports 2019[5]. Preconditioning costs were also obtained from the KSU Enterprise Report 2019 under the Beef-Backgrounding Report, and the finishing costs were obtained from the Beef-Backgrounding/Finishing Report from the same source. Non-feed-related preconditioning costs were obtained from Dhuyvetter et al. (2005) and Donnell et al. (2008).

The stochastic performance parameters, ADG, sick rate, and death rate, of preconditioned and non-preconditioned cattle at the feedlot were obtained from Avent (2002). We followed Verteramo Chiu et al. (2022) by fitting Program Evaluation and Review Technique (PERT) distributions to the performance parameter estimated by Avent (2002) to capture the stochastic performance of cattle in the feedlot. We simulated using non-correlated performance parameters. A scenario including correlation among performance variables is presented in the Appendix. The distribution of the performance parameters (Verteramo Chiu et al., 2022) is shown in Table 1.

[5]https://www.agmanager.info/kfma/kfma-enterprise-reports, 2014-2018 average.

https://doi.org/10.1017/age.2025.10

Table 1. Distribution parameters used to fit a PERT distribution on ADG

Performance variables	Average	Min	Mode	Max	SD	Lambda
ADG (lbs), Preconditioned	2.93	2.34	2.78	3.59	0. 337	0.429
ADG (lbs), Non-Preconditioned	2.56	1.70	2.67	3.31	0.375	1.516
% Sick, Preconditioned	9.23	1.5	2	25	5.447	1.11
% Sick, Non-Preconditioned	36.43	12.5	26.8	70	14.172	1
% Dead, Preconditioned	1.57	0.5	0.5	3	0.678	0.333
% Dead, Non-Preconditioned	4.26	2	2	10	1.694	1.53

ADG is average daily gain. Average, minimum, and maximum were obtained from Avent (2002). Mode and Lambda were calibrated to fit each PERT distribution to the values estimated by Avent (2002) Standard deviation (SD) is the result of the PERT distribution estimated. See the Appendix for more information on the distribution estimation process.

The preconditioning market price premium paid by the buyer reflects the expected gains over non-preconditioned cattle in the feedlot. These gains are stochastic since the performance of cattle depends on many factors, including a genetic component, and upbringing by the cow-calf operator, factors not observed by the buyer, although genetics of entering cattle can be tested using a random sample of the calves (Thompson et al., 2014), but near-time genetic results may not be feasible now[6]. The price premium, therefore, is the expected gain accounting for any stochastic variation. This stochastic performance can be better estimated from the genetics and a reputational component of the seller. In lieu of reputation and genetics information, the feedlot can establish contracts with the cow-calf operator that allows cattle performance risk to be shared optimally between the parties. The parameter values used in this analysis are presented in Table 2.

Price and cost data obtained from https://www.agmanager.info/kfma/kfma-enterprise-reports, 2014–2018 average. The weight of finished cattle, weaned calves, and backgrounded and preconditioned calves are 1400, 550, and 618 lb, respectively. Non-feed-related preconditioning costs were obtained from Dhuyvetter et al. (2005) and Donnell et al. (2008). Standard deviation in parenthesis. C_p and C_{np} represent the market price of the incoming animal to the feedlot, differences are due to feedlot entry weights. $E(\pi)$ includes the cost of the incoming animal, C_p or C_{np}. $E(FC)$ does not include the cost of incoming animal. Grid pricing is not included for simplicity in the analysis.

The average benefits to the feedlot of purchasing preconditioned cattle over non-preconditioned cattle, assuming the feedlot pays a price premium that covers the costs of preconditioning ($25.60), is about $24 per head. This is the difference between the expected net revenue to feedlot of a preconditioned and non-preconditioned calves (about $50) minus preconditioning costs. The net benefit to the feedlot is about $50 per head if no price premium is paid for preconditioned cattle. The net benefit to the feedlot of $50 per head can be transferred, partially, to the producer to motivate preconditioning. The amount transferred to the producer to incentivize preconditioning depends on personal preferences, at a minimum it should cover preconditioning costs. The expected net revenue to feedlot per preconditioned and non-preconditioned cattle was calculated to be

[6]Genetic information on the cattle would compress the stochastic variation of returns.

Table 2. Parameter values used in the baseline budget model for the beef production system described in Figure 1

Parameter name	Value ($/ head)
P (finished cattle price)	$1792.7
$E(\pi)$ (expected net revenue to feedlot)	
- Per preconditioned cattle, π_p	−$106.64
- Per non-preconditioned cattle, π_{np}	−$156.39
$E(FC)$ (expected total feedlot cost of finishing cattle)	
- Per preconditioned cattle, FC_p	$808.56
- Per non-preconditioned cattle, FC_{np}	$957.22
C, Cost of an incoming animal to feedlot	
- Per preconditioned cattle, C_p	$1090.77
- Per non-preconditioned cattle, C_{np}	$991.87
Preconditioning Cost	$25.60
Interest rate, *irate*[7]	0.0327

negative. Net revenue per head depends on many factors, including feed costs, feedlot fees, and finished cattle price, which are stochastic. The negative revenue per head does not affect the interpretation of our results, since our focus is on the net revenue difference between preconditioned vs non-preconditioned calves.

Results

Net return distributions including preconditioning premium

As an initial analysis, we ran 10,000 iterations of the simulated net return for preconditioned and non-preconditioned cattle using the performance distribution parameters of Table 1. The performance distributions were simulated from independently random draws, and the net returns simulated included a preconditioning premium to the producer. The distribution functions are shown in Figure 2.

For the cow-calf operators to receive a price premium for their calves, the feedlot operator must be certain that the animals are preconditioned. Preconditioning assurance is transmitted through certification or reputation. The expected return due to preconditioning should be greater than the cost of preconditioning. The price premium necessary to incentivize preconditioning should, at a minimum, cover preconditioning costs, and at the maximum be the totality of the net benefits of preconditioning to the feedlot.

We present the probability densities of net returns per animal of the two preconditioned status cattle (P and NP) in Figure 2, with a price premium that covers the estimated preconditioning costs, that is, the minimum price premium. Under this scenario, no distribution stochastically dominates the other in the first order; however, the distribution of net returns per animal for preconditioned cattle continues to dominate in

[7] 1 year CD, May 16, 2022. https://www.fdic.gov/resources/bankers/national-rates/index.html

https://doi.org/10.1017/age.2025.10

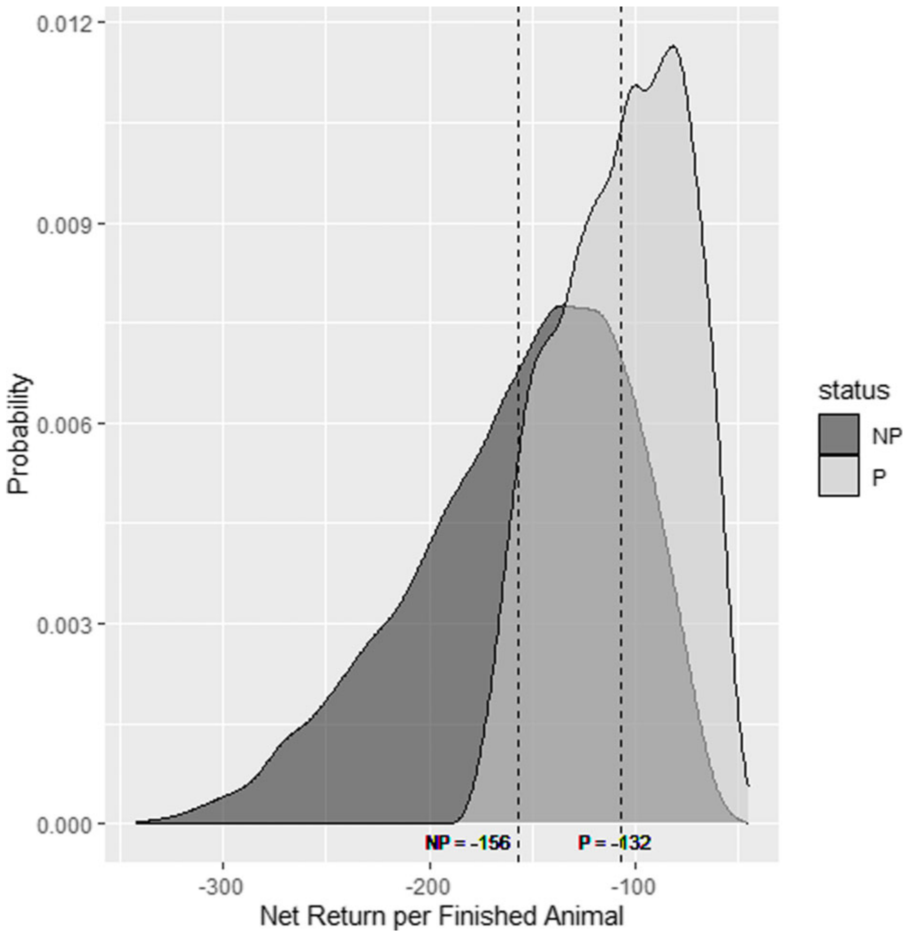

Figure 2. Probability density functions of net returns to the feedlot for preconditioned (P) and non-preconditioned (NP) cattle including preconditioning costs. Dashed lines represent the average net returns for each preconditioning status. Ten thousand iterations were simulated for each distribution.

the second order. A risk-averse feedlot operator would prefer preconditioned cattle because it has a higher mean without exposing them to a larger downside risk compared to non-preconditioned cattle, despite having a lower right tail; a sufficiently high risk-seeking feedlot operator may prefer non-preconditioning cattle under this condition.

The net revenue of the feedlot when paying the cow-calf operator the cost of production for each type of cattle are −\$132 ($SD = 30.44$) and −\$156 (SD = 52.36) per head of preconditioned and non-preconditioned cattle, respectively. Negative returns are not uncommon in beef production and were observed in our sample data. Our results represent economic returns and are dependent on relative input and output prices, which are variable in any time period.

The price premium is calculated as the difference of mean net returns, which is \$49.76 per head, or \$8.05/ cwt for a 618 lb. animal. When the feedlot transfers the maximum price premium (not shown), the distribution of non-preconditioned cattle is a nonsymmetrical mean preserving spread of the preconditioned cattle distribution. In this scenario, non-preconditioned cattle generate lower net return per head to the feedlot as well as higher net return per head to the feedlot than preconditioned cattle. A risk-averse feedlot operator would prefer to purchase preconditioned cattle over non-preconditioned cattle, due to the negatively skew distribution of net returns of non-preconditioned cattle, even when the benefit of preconditioned cattle to the feedlot is transferred to the producer as price premium.

The factors affecting the shape of the distribution of net returns to the feedlot for each preconditioning status of the animal may depend on random factors external to the cow-calf operator and the feedlot, but some idiosyncratic effects may also be present. External factors may include adverse weather conditions and epidemics; while idiosyncratic factors may include genotype of the cattle, feed quality, facility hygiene, and management experience among others. The distributions of net returns to the feedlot shown in Figure 1A represent all types of feedlots (efficient and inefficient), and all cattle quality (improved genotype). Efficient feedlots are on the right part of the distributions, while inefficient ones are on the left part of the distributions. This point will be addressed later in the paper.

Contract design

A contract is designed by the feedlot which maximizes its expected returns per animal while providing an incentive to cow-calf operators to participate in the contract. From the cow-calf operator side, they have the choice to sell their cattle at the cash market or participate in a contract which may allow them to receive larger returns. Some producers retain ownership of their cattle, reaping all benefits. The difference in returns to the cow-calf operator from participating in the contract depends on the quality of the cattle (unobserved to the feedlot but known to the cow-calf operator) and the quality of the feedlot (experienced management, adequate facilities, and quality inputs), which is built on reputation and known to the cow-calf operator. First, we look at the situation assuming homogeneity in both cow-calf operators and feedlots, implying that the net return distributions depend on external factors only. This scenario does not separate feedlots by management quality.

The payoffs to the producer and feedlot from a contract designed are presented in Table 3, Where $\alpha \in [0, 1]$ is the share of the net return of the finished cattle received by the feedlot, and $(1-\alpha)$ is the share received by the cow-calf operator. β is a fixed amount paid to the cow-calf operator. C_k is the cost of production of an animal of type k, Rev_k is the net revenue to the feedlot of selling an animal of type k, where k is preconditioned or non-preconditioned

In Table 4 we show the profit under various values of α and β offered to risk-neutral producer of preconditioned and non-preconditioned cattle. The parameter α is the percentage of the net return of finished cattle that is distributed to the feedlot. At each combination of contract parameters, the net return to the feedlot (−$132 and −$156/ head of preconditioned and non-preconditioned cattle, respectively) as well as the net return to the calf producer ($0/ head for both preconditioned and non-preconditioned cattle) are the same, and the risk-neutral producer is indifferent among the contract parameter combination since their certainty equivalent is 0 for any combination of contract parameters. The negative net returns to the feedlot include all feedlot-related fees and costs.

$\alpha \in [0, 1]$ is the share of the net return of the finished cattle received by the feedlot, and $(1-\alpha)$ is the share received by the cow-calf operator. β is a fixed amount paid to the

https://doi.org/10.1017/age.2025.10

Table 3. Payoff matrix to the producer and feedlot by animal type

	Feedlot Preconditioned	Feedlot Non-Preconditioned
Producer Preconditioned	$\alpha Rev_p - \beta$ $(1-\alpha)Rev_p + \beta - C$	
Producer Non-Preconditioned		$\alpha Rev_{np} - \beta$ $(1-\alpha)Rev_{np} + \beta - C$

Table 4. Contract distribution of α and β for a risk-neutral cow-calf operator of preconditioned and non-preconditioned cattle

α	0.00	0.10	0.30	0.50	0.70	0.90	1.00
Preconditioned, β	132.23	230.65	427.48	624.30	821.13	1017.96	1116.37
Non-Preconditioned, β	156.39	239.94	407.04	574.13	741.23	908.32	991.87

cow-calf operator by the feedlot in dollars per head. Net return per head to the feedlot and to the producer is the same regardless of the values of α and β specified in the contract for each calf type.

From Table 4, a risk-neutral calf producer would enter a contract when he receives half of the net return ($\alpha = 0.5$) of a fed animal plus an additional \$624 per animal if the calf is preconditioned and \$574 if the calf is non-preconditioned, which are the corresponding values of β. The net return per animal accounts for feedlot fees and all costs of production. When the calf producers retain ownership of the calf ($\alpha = 0$), he is expected to receive a smaller fixed amount from the feedlot to enter the contract (\$132 and \$156 per preconditioned and non-preconditioned animal, respectively). A single contract that would satisfy both types of calf producers (preconditioned and non-preconditioned) in terms of making their CE = 0 (or indifferent between entering the contract or selling at the cash market) consists of $\alpha = 0.16$ and $\beta = 290$.

When the calf producer is moderately risk averse and the feedlot operator risk neutral, the optimal solution to the principal-agent problem is a corner solution where $\alpha = 1$. The Arrow-Pratt absolute risk aversion coefficient of a moderate risk-averse producer, about $r = 0.001$, results from rescaling the Arrow-Pratt absolute risk aversion coefficient by the expected return to producers from producing preconditioned and non-preconditioned cattle, \$1040 per head on average, to reach a relative risk aversion coefficient of 1. Similarly, the moderate risk aversion coefficient for the feedlot operator is $r = 0.0006$, based on the expected return of \$1793 per finished animal. Risk neutrality is generally assumed when decision-makers can spread out their risk through a large portfolio. Business operators may show risk aversion, depending on their incentives. When feedlot operators show risk aversion, the optimal contract design differs from the risk-neutral scenario. We analyzed optimal contracts under the assumption of a moderately risk-averse feedlot operator and under the assumption of a higher risk aversion of the producer ($r = 0.001$). The results are shown in Table 5.

https://doi.org/10.1017/age.2025.10

Table 5. Optimal solution under various risk preference scenarios for calf producers and feedlot operators

Risk preference	Contract Preconditioned	Contract Non-Preconditioned	Feedlot Profit Preconditioned	Feedlot Profit Non-Preconditioned
Producer $r = 0.001$ Feedlot Operator $r = 0$	$\alpha = 1$ $\beta = 1116.37$	$\alpha = 1$ $\beta = 991.87$	−132.23	−156.39
Producer $r = 0.001$ Feedlot Operator $r = 0.0006$	$\alpha = 0.62$ $\beta = 742.47$	$\alpha = 0.62$ $\beta = 674.59$	−132.30	−156.59
Producer $r = 0.01$ Feedlot Operator $r = 0.0006$	$\alpha = 0.94$ $\beta = 1057.34$	$\alpha = 0.94$ $\beta = 941.79$	−132.25	−156.44

$\alpha \in [0, 1]$ is the share of the net return of the finished cattle received by the feedlot, and $(1 - \alpha)$ is the share received by the cow-calf operator. β is a fixed amount paid to the cow-calf operator by the feedlot in dollars per head. r is the Arrow-Pratt risk aversion coefficient.
The value of α gravitates away from the risk-averse party. Under the scenario where the producer risk aversion value is 0.001 and that of the feedlot operator is 0.0006 the optimal contract has an estimated α value of 0.94.

Allowing for differences in feedlot management

We account for heterogeneities in feedlot infrastructure and managerial skills, as well as any differences in cattle management and transportation, by dividing the net return distribution for both preconditioning status of cattle into three percentiles: lower than 25$^{\text{th}}$, 25$^{\text{th}}$–75$^{\text{th}}$, and higher than 75$^{\text{th}}$. We name these three parts as low, average, and high management quality, respectively. Differences in feedlot management have been reported by APHIS (APHIS-VS, 2013) as familiarity with Beef Quality Assurance programs and management practices that affect beef quality across various feedlot sizes and regions of operation. Other industry reports state differences, by feedlot size, in the frequency of using the same equipment to handle manure and feed (APHIS, 2012). Any factors endogenous to the cow-calf operator, other than the preconditioning status of the cattle, affecting the net return distribution of the feedlot are not considered.

The statistics of the net return distribution across the three feedlot management levels are presented in Table 6.

Number of iterations for each management quality: high, 2500; average, 5000; low, 2500. P and NP refer to preconditioned and non-preconditioned cattle, respectively.

From Table 6 we can obtain the maximum preconditioning premium paid by the feedlot to the calf producer depending on the feedlot's management quality (High, Average, Low). These are $4.40, $7.32, and $13.15/ cwt, corresponding to a preconditioning premium per animal of $27.19, $45.28, and $81.28, for high, average, and low management quality feedlots, respectively.

The net return distribution of preconditioned cattle in principle should at least cover the cost of preconditioning paid to the cow-calf operator, making him indifferent to preconditioning or not. For clarity, we present the net return distribution of the low and high feedlot quality levels, including preconditioning costs ($4.14/ cwt), in Figure 3.

Figure 3 shows that under low feedlot management quality, net returns from preconditioned cattle stochastically dominate in the first order over non-preconditioned

https://doi.org/10.1017/age.2025.10

Table 6. Sample statistics of net returns in $ per animal at feedlot under three management levels, High, Average, and Low and the two preconditioning status, P preconditioned, NP non-preconditioned. Preconditioning costs not included

Feedlot management level and preconditioning status	Min	Average	Max	Stdev
High P	−81.54	−69.32	−45.19	8.31
High NP	−116.03	−96.51	−56.19	13.37
Average P	−130.25	−104.57	−81.54	13.89
Average NP	−189.74	−149.86	−116.04	20.75
Low P	−182.98	−148.06	−130.27	11.64
Low NP	−342.09	−229.34	−189.78	30.52

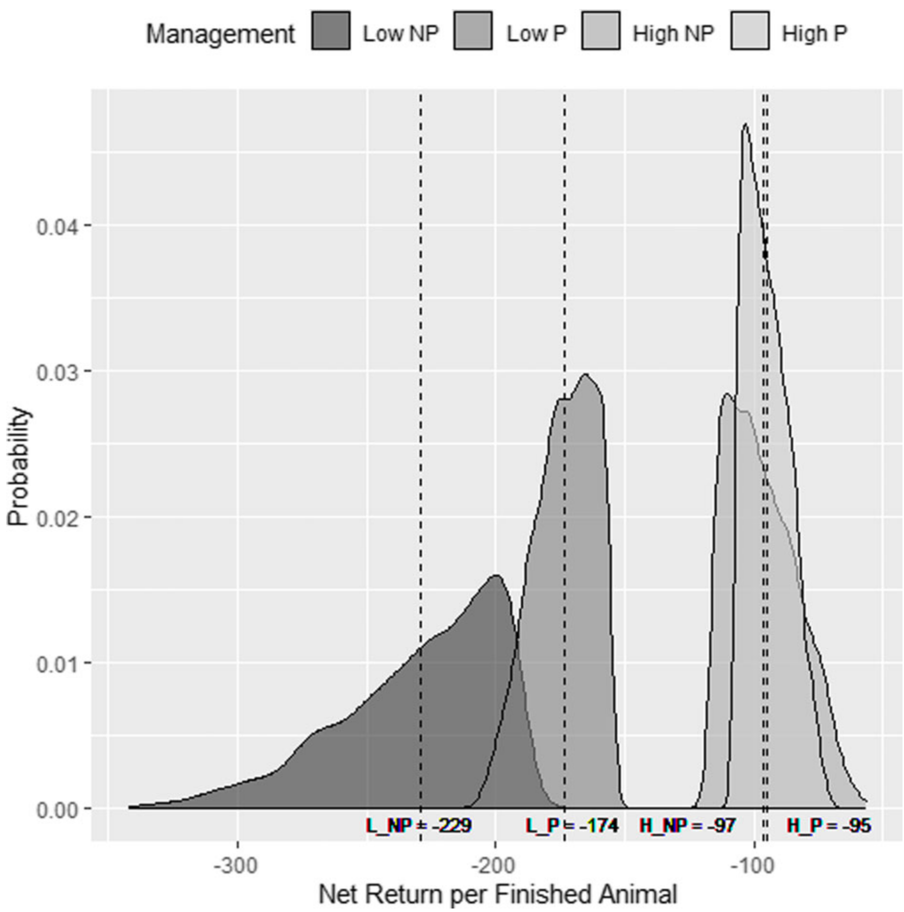

Figure 3. Probability density functions of net returns to the feedlot, under high (H) and low (L) feedlot management level, for preconditioned (P) and non-preconditioned (NP) cattle including preconditioning costs. Dashed lines represent the average net returns for each management level and preconditioning status. Each distribution was simulated with 2500 iterations.

https://doi.org/10.1017/age.2025.10

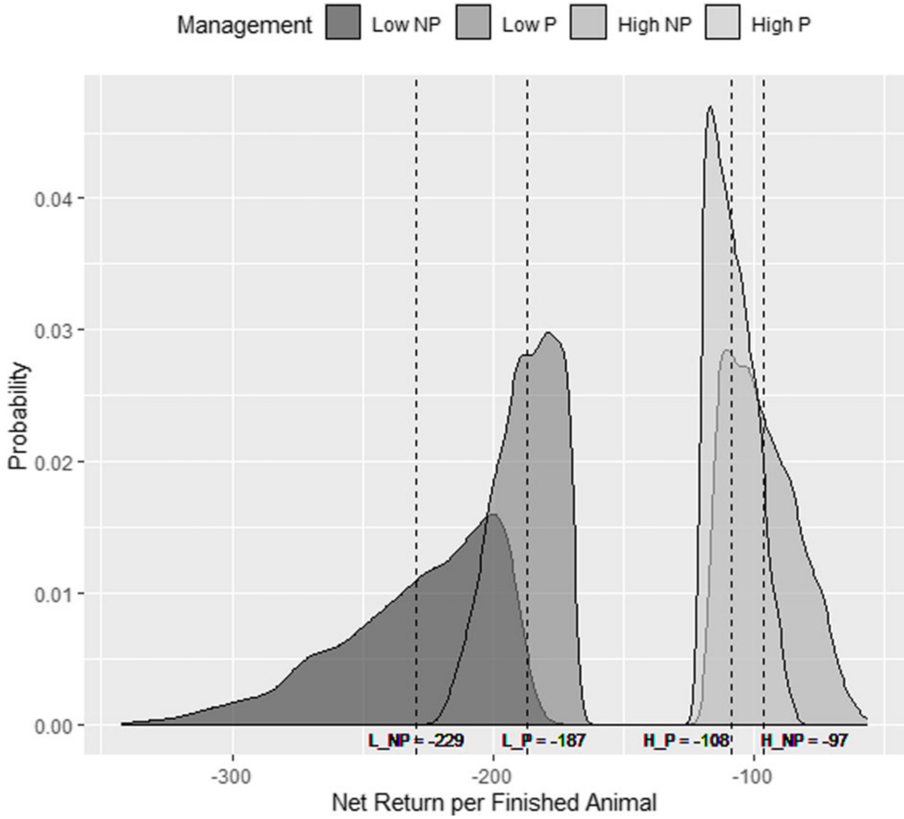

Figure 4. Probability density functions of net returns to the feedlot, under high (H) and low (L) feedlot management level, for preconditioned (P) and non-preconditioned (NP) cattle including the mean preconditioning premium for 600–700 lbs cattle of $6.32/cwt. Dashed lines represent the average net returns for each management level and preconditioning status. Each distribution was simulated with 2500 iterations.

cattle. In the case of high feedlot management quality, net returns from preconditioned cattle stochastically dominates in the second order over non-preconditioned cattle. Low-quality feedlot management would always prefer preconditioned cattle.

The price premium is expected to cover more than preconditioning costs to incentivize preconditioning. In a recent study on cattle auctions, Mitchell (2020) estimated preconditioning premia ranged between $7.59 and $9.03/ cwt, with a mean of $8.31/ cwt for cattle weight between 500 to 600 lbs, and between $5.49 to $7.15 with a mean of $6.32/ cwt for cattle weight between 600 to 700 lbs. Our estimated cost of preconditioning a 618 lb cattle is $4.14/ cwt, which is 65% of the mean premium for 600–700 lbs cattle. Our estimated preconditioning net benefit of $8.05/ cwt is in line with the average for 500 to 600 lbs cattle. Using the mean preconditioning premium of $6.32/ cwt as reference implies a preconditioning premium of $39 for a 618 lb animal or $13.46 over the preconditioning cost per animal. The distributions of the two feedlot management qualities for the two

https://doi.org/10.1017/age.2025.10

preconditioning status cattle, when the mean preconditioning premium of \$6.32/ cwt is included, are shown in Figure 4.

Under the scenario depicted in Figure 4, preconditioned cattle no longer stochastically dominate non-preconditioned cattle in the first nor second order for high-quality feedlot management. The expected net return of preconditioned cattle with a preconditioning premium of \$6.32/ cwt under high-quality feedlot management is lower than that of non-preconditioned cattle (-\$108 and -\$97, respectively). Non-preconditioned cattle first-order stochastically dominates preconditioned cattle for high-quality management, however, for low-quality management feedlots, preconditioned cattle continue to stochastically dominate in the first order. An implication of these results is that feedlots operating under high-quality management would prefer non-preconditioned over preconditioned cattle with a premium of \$6.32/ cwt. Similarly, low-quality management feedlots benefit the most when purchasing preconditioned over non-preconditioned cattle.

If the preconditioning premium only covers the cost of preconditioning, high-quality feedlot managers would prefer to purchase preconditioned cattle over non-preconditioned since it would stochastically dominate in first order (not illustrated). Figure 4 shows that when the preconditioning premium is the average market premium of \$6.32/ cwt, it can be sufficiently high as to make the high-quality management feedlot prefer non-preconditioned over preconditioned cattle. For medium-quality feedlot management, the preconditioning price premium must be larger than \$6.32/ cwt to make preconditioning cattle too expensive for feedlots, for low-quality feedlot management, the premium must be much larger for the feedlot manager to prefer non-preconditioned over preconditioned cattle.

The simulated optimal contract design for feedlots under the three management levels and various levels of risk aversion are shown in Table 7.

When the feedlot operators behave as if they are risk averse, an optimal contract can be constructed that is preferable to taking full ownership of the incoming cattle. Depending on the management level of the feedlot, the fixed payment to the calf producer differs, but not the optimal profit share per animal.

An observation from Table 7 is that high-management feedlots find the returns of non-preconditioned cattle comparable to those of preconditioned cattle. The difference in profit per animal of preconditioned vs non-preconditioned, from Table 7, is about 1.7% for a high-management feedlot and about 15% for a medium management feedlot. Medium and low-management feedlots would be willing to pay a higher premium than high-management feedlots.

Contracts when preconditioning status cannot be certified

When calf producers precondition cattle but are not enrolled in any certification protocol, the feedlot operator can develop a single contract for all preconditioning status cattle that incentivizes preconditioning. This scenario is similar to a case where cattle quality (genetics, producer management) cannot be observed by the buyer. The contract should disincentivize the non-preconditioned calf producer from selling at a feedlot by linking the calf payment to feedlot performance. The CE of the non-preconditioned producer is negative (indicating a disutility compared to selling at the cash market), while that of the preconditioned producer is non-negative. In all risk preference scenarios, the optimal single contract always gives the calf producer full ownership of their cattle ($\alpha = 0$). For clarity we only present the results, in Table 8, of the optimal single contract for low, high, and all quality management. Because the optimal contract is $\alpha = 0$, the risk preference of the feedlot operator is not relevant.

https://doi.org/10.1017/age.2025.10

https://doi.org/10.1017/age.2025.10

Table 7. Optimal solution under various scenarios of risk preference for calf producers and feedlot operators

Risk preference	Contract Preconditioned	Contract Non-Preconditioned	Feedlot Profit Preconditioned	Feedlot Profit Non-Preconditioned
Producer $r = 0.001$ Feedlot Operator $r = 0$				
Management Efficiency: Low	$\alpha = 1$ $\beta = 1116.37$	$\alpha = 1$ $\beta = 991.87$	−173.66	−229.34
Med			−130.18	−149.86
High			−94.92	−96.51
Producer $r = 0.001$ Feedlot Operator $r = 0.0006$	$\alpha = 0.63$	$\alpha = 0.63$		
Management Efficiency: Low	$\beta = 758.15$	$\beta = 702.18$	−173.67	−229.41
Med	$\beta = 751.49$	$\beta = 680.36$	−130.19	−149.89
High	$\beta = 738.44$	$\beta = 660.60$	−94.93	−96.53
Producer $r = 0.01$ Feedlot Operator $r = 0.0006$	$\alpha = 0.94$	$\alpha = 0.94$		
Management Efficiency[1]: Low	$\beta = 1059.81$	$\beta = 946.14$	−173.67	−229.36
Med	$\beta = 1057.20$	$\beta = 941.36$	−130.18	−149.87
High	$\beta = 1055.08$	$\beta = 938.15$	−94.93	−96.52

[1]Management Efficiency refers to Feedlot Operators. $\alpha \in [0, 1]$ is the share of the net return of the finished cattle received by the feedlot, and $(1 - \alpha)$ is the share received by the cow-calf operator. β is a fixed amount paid to the cow-calf operator by the feedlot in dollars per head. r is the Arrow-Pratt risk aversion coefficient.

Table 8. Optimal single contract design under two scenarios of risk preference for the producer, assuming risk neutrality of the feedlot operator

Risk preference	Contract	CE non-preconditioned producer	Feedlot profit preconditioned	Feedlot profit non-preconditioned
Producer $r = 0$ Feedlot Operator $r = 0$				
Management Efficiency: All Levels	$\alpha = 0$ $\beta = 132.24$	−24.16	−132.24	−132.24
Low	$\alpha = 0$ $\beta = 173.66$	−55.68	−173.66	−173.66
High	$\alpha = 0$ $\beta = 94.92$	−1.59	−94.92	−94.92
Producer $r = 0.001$ Feedlot Operator $r = 0.0$				
Management Efficiency[1]: All Levels	$\alpha = 0$ $\beta = 132.70$	−25.07	−132.70	−132.70
Low	$\alpha = 0$ $\beta = 173.73$	−56.08	−173.73	−173.73
High	$\alpha = 0$ $\beta = 94.96$	−1.64	−94.96	−94.96

[1]Management Efficiency refers to Feedlot Operators. $\alpha \in [0, 1]$ is the share of the net return of the finished cattle received by the feedlot, and $(1 - \alpha)$ is the share received by the cow-calf operator. β is a fixed amount paid to the cow-calf operator by the feedlot in dollars per head. r is the Arrow-Pratt risk aversion coefficient.

One contract for all incoming cattle, regardless of the preconditioning status, certification, or producer reputation, can be created that incentivizes producers of preconditioned cattle to accept while disincentivizing non-preconditioned cattle producers from accepting. All single contract specification sets $\alpha = 0$, and β to different values depending on the risk preference of the producer and the management level of the feedlot. The disincentive for non-preconditioned cattle producers (as captured in their CE) is larger for low-quality management feedlots. In fact, the disincentives for non-preconditioned cattle producers are very small for high-quality management feedlots.

Conclusion

Our study illustrates how an agricultural value chain with heterogeneous processors and suppliers can use optimal contracts to price inputs of various qualities. We used the US beef value chain as an illustration of how a risk-sharing contract in which the ownership of the cattle is retained throughout the feedlot is analyzed. An important result is that

https://doi.org/10.1017/age.2025.10

efficient processors may not value certain input quality attributes as much as less efficient processors, where both processors produce the same output, and the quality attribute of the input affects production efficiencies. This approach can be used to analyze other food value chains in which inputs can be supplied with different quality levels and where the buyers of those inputs are food processors that value quality differently.

We simulated the net return distribution to the feedlot of preconditioned and non-preconditioned cattle and created optimal contracts under various performance conditions that allow the feedlot to incentivize preconditioned cattle producers to offer their calves to the feedlot while disincentivizing non-preconditioned cattle from entering the feedlot. We found that when the producer is risk averse and the feedlot operator is risk neutral, the optimal solution is for the feedlot to take full ownership of the incoming cattle and resultant revenue. However, when the feedlot operator shows some degree of risk aversion, the share of the revenue of the finished cattle given to the producer is non-zero.

The optimal contract differs by assumptions of feedlot management quality. We found that high-management feedlots favor almost equally desirable preconditioned as well as non-preconditioned cattle. Low-quality management feedlots benefit the most from introducing preconditioned cattle to their feedlot operation.

When preconditioning cannot be certified, a single contract can be developed that maximizes feedlot revenue while incentivizing preconditioning cattle offers.

Our study illustrates that although preconditioning cattle can be sold at a premium, certain types of feedlots may be indifferent between purchasing preconditioned or non-preconditioning. Our analysis helps explain why preconditioning is not a dominant strategy for calf producers.

Certifications of quality features that improve processing and transportation efficiencies require a cost and time commitment from producers, which in some cases may not be reflected in higher prices received by producers.

Data availability statement. The data used in the model are publicly available and referenced in the manuscript.

Funding statement. This research was supported by the Agriculture and Food Research Initiative Competitive Grant no. 2016-68003-24607 from the USDA National Institute of Food and Agriculture and faculty research accounts from the Cornell Veterinary College and the Cornell SC Johnson College of Business.

Competing Interests. The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

APHIS-VS 2012. *Biosecurity on U.S. Feedlots*, APHIS Info Sheet, July 2012. Available at https://www.aphis.usda.gov/animal_health/nahms/feedlot/downloads/feedlot2011/Feed11_is_Biosecurity_1.pdf

APHIS-VS 2013. *Awareness of the Beef Quality Assurance Program Among Operators of Small Feedlots*, APHIS Info Sheet, April 2013. Available at https://www.aphis.usda.gov/animal_health/nahms/feedlot/downloads/feedlot2011/Feed11_is_BQA_1.pdf

Avent, RK 2002. "Market Value, Feedlot Performance, and Profitability of a Preconditioned Calf." Unpublished M.S. thesis, Oklahoma State University, August 2002.

Avent RK, Ward CE and Lalman DL 2007. *Economic Value of Preconditioning Feeder Calves.* Oklahoma Agricultural Experimental Station Fact Sheet AGEC-583. Oklahoma State Univ., Stillwater, OK. Available at “”http://pods.dasnr.okstate.edu/docushare/dsweb/Get/Document-1969/AGEC-583web.pdf

Barrett CB, Bachke ME, Bellemare MF, Michelson HC, Narayanan S and Walker TF 2012. Smallholder participation in contract farming: comparative evidence from five countries. *World Development* **40**(4), 715–730. https://doi.org/10.1016/j.worlddev.2011.09.006

Barrett CB, Reardon T, Swinnen J and Zilberman D 2022. Agri-food value chain revolutions in low-and middle-income countries. *Journal of Economic Literature* **60**(4), 1316–1377. https://doi.org/10.1257/jel.20201539

Bellemare MF and Bloem JR 2018. Does contract farming improve welfare? A review. *World Development* **112**, 259–271. https://doi.org/10.1016/j.worlddev.2018.08.018

Bulut H and Lawrence JD 2007. The value of third-party certification of preconditioning claims at Iowa feeder cattle auctions. *Journal of Agricultural and Applied Economics* **39**(3), 625–640. https://doi.org/10.1017/S1074070800023312

Chymis AG, James Jr HS, Konduru S, Pierce VL and Larson RL 2007. Asymmetric information in cattle auctions: The problem of revaccinations. *Agricultural Economics* **36**(1), 79–88. https://doi.org/10.1111/j.1574-0862.2007.00178.x

Cravey MD 1996. "Preconditioning Effect on Feedlot Performance." In: Proc. Southwest Nutrition and Management Conference, Phoenix, AZ.

Curzi D, Raimondi V and Olper A 2015. Quality upgrading, competition and trade policy: Evidence from the agri-food sector. *European Review of Agricultural Economics* **42**(2), 239–267. https://doi.org/10.1093/erae/jbu021

DeLong KL, Jensen KL, Griffith AP, Boyer CN and Martinez CC 2023. Feeder cattle genomic tests: Analyzing cattle producer adoption decisions. *Journal of the Agricultural and Applied Economics Association* **2**(2), 334–349. https://doi.org/10.1002/jaa2.61

DeVuyst EA, Biermacher JT, Lusk JL, Mateescu RG, Blanton Jr JB, Swigert JS, Cook BJ and Reuter RR 2011. Relationships between fed cattle traits and Igenity panel scores. *Journal of Animal Science* **89**(5), 1260–1269. https://doi.org/10.2527/jas.2009-2372

Dhuyvetter KC, Bryant AM and Blasi DA 2005. CASE STUDY: Preconditioning beef calves: are expected premiums sufficient to justify the practice? *The Professional Animal Scientist* **21**(6), 502–514. https://doi.org/10.15232/S1080-7446(15)31256-0

Dhuyvetter KC 2004. Economics of preconditioning calves. *Kansas State University Agricultural Leaders Conference*, Vol. 29. 2004. Manhattan, KS.

Donnell J, Ward CE and Swigert S 2008. Costs and Benefits Associated with Preconditioning Calves. *Oklahoma Cooperative Extension Service Fact Sheet AGEC 247*. Available at http://osufacts.okstate.edu

Earley B, Sporer KB and Gupta S 2017. Invited review: Relationship between cattle transport, immunity and respiratory disease. *Animal* **11**(3), 486–492. https://doi.org/10.1017/S1751731116001622

Fausti S, Johnson B, Epperson W and Grathwohl N 2003. "Risk and the economic incentive to retain ownership of steer calves." Staff paper, Brookings: Economics Department, South Dakota State University. Available at https://openprairie.sdstate.edu/econ_staffpaper/171/

Gaigné C and Gouel C 2022. Trade in agricultural and food products. *Handbook of Agricultural Economics* **6**, 4845–4931. https://doi.org/10.1016/bs.hesagr.2022.03.004

Galyean ML, Duff GC and Rivera JD 2022. Galyean Appreciation Club Review: revisiting nutrition and health of newly received cattle—What have we learned in the last 15 years? *Journal of Animal Science* **100**(4), skac067. https://doi.org/10.1093/jas/skac067

Garber B, Alwang J, Norton G and Bovay J 2022. Beef and the bottom line: The effect of value-added certification on feeder cattle profitability. *Journal of Agricultural and Applied Economics* **54**(1), 157–174. https://doi.org/10.1017/aae.2021.33

Griebel P, Hill K and Stookey J 2014. How stress alters immune responses during respiratory infection. *Animal Health Research Reviews* **15**(2), 161–165. https://doi.org/10.1017/S1466252314000280

Hilton WM 2015. Management of preconditioned calves and impacts of preconditioning. *Veterinary Clinics: Food Animal Practice* **31**(2), 197–207. https://doi.org/10.1016/j.cvfa.2015.03.002

King RP, Backus GB and Van Der Gaag MA 2007. Incentive systems for food quality control with repeated deliveries: Salmonella control in pork production. *European Review of Agricultural Economics* **34**(1), 81–104. https://doi.org/10.1093/erae/jbl030

Lalman D and Ward CE 2005. Effects of preconditioning on health, performance and prices of weaned calves. *In American Association of Bovine Practitioners Conference Proceedings*, pp. 44–50. https://doi.org/10.21423/aabppro20054792

Lawrence JD 2005. *Retained Ownership Strategies for Cow Herds.* Ames: Iowa State University Cooperative Extension Service, Bulletin M-1726. Available at https://econpapers.repec.org/paper/isugenres/12462.htm

Maples WE, DeVuyst EA and Wade Brorsen B 2022. Performance-based contracts in cattle feedlots. *Journal of the Agricultural and Applied Economics Association* **1**(1), 82–92. https://doi.org/10.1002/jaa2.10

Meemken EM and Bellemare MF 2020. Smallholder farmers and contract farming in developing countries. *Proceedings of the National Academy of Sciences* 117(1), 259–264. https://doi.org/10.1073/pnas.1909501116

Michelson HC 2013. Small farmers, NGOs, and a Walmart world: Welfare effects of supermarkets operating in Nicaragua. *American Journal of Agricultural Economics* **95**(3), 628–649.

Mitchell JL 2020. Estimates of the Premium for Preconditioned Cattle. *Cooperative Extension Service*, University of Arkansas, FSA3153-PD-9-20. Available at https://www.uaex.uada.edu/publications/pdf/FSA3153.pdf

OQBN 2019. OQBN Premium over Calves Marketed with No Preconditioning. Available at http://oqbn.okstate.edu/oqbn-sale-results/2019-sale-results

Otsuka K, Nakano Y and Takahashi K 2016. Contract farming in developed and developing countries. *Annual Review of Resource Economics* **8**, 353–376. https://doi.org/10.1146/annurev-resource-100815-095459

Pingali P, Khwaja Y and Meijer M 2007. The role of the public and private sectors in commercializing small farms and reducing transaction costs. In Swinnen JFM (ed), *Global Supply Chains, Standards and the Poor*. Oxford, UK: CABI International, pp. 267–280. https://doi.org/10.1079/9781845931858.0267

Resende-Filho MA and Buhr BL 2008. A principal-agent model for evaluating the economic value of a traceability system: A case study with injection-site lesion control in fed cattle. *American Journal of Agricultural Economics* **90**(4), 1091–1102. https://doi.org/10.1111/j.1467-8276.2008.01150.x

Schulz LL, Dhuyvetter KC and Doran BE 2015. Factors affecting preconditioned calf price premiums: Does potential buyer competition and seller reputation matter? *Journal of Agricultural and Resource Economics* **40**(2), 220–241. http://www.jstor.org/stable/44131859

Starbird SA 2005. Moral hazard, inspection policy, and food safety. *American Journal of Agricultural Economics* **87**(1), 15–27. https://doi.org/10.1111/j.0002-9092.2005.00698.x

Tang M, Lewis K, Lambert D, Griffith A and Boyer C 2017. Beef cattle retained ownership and profitability in Tennessee. *Journal of Agricultural and Applied Economics* **49**(4), 571–591. https://doi.org/10.1017/aae.2017.12

Thompson NM, DeVuyst EA, Brorsen BW and Lusk JL 2014. Value of genetic information for management and selection of feedlot cattle. *Journal of Agricultural and Resource Economics* **39**(1), 139–155. https://www.jstor.org/stable/44131319

Thrift FA and Thrift TA 2011. REVIEW: Update on preconditioning beef calves prior to sale by cow-calf producers. *The Professional Animal Scientist* **27**(2), 73–82. https://doi.org/10.15232/S1080-7446(15)30452-6

USDA:NAHMS 2013. Feedlot 2011. Available at https://www.aphis.usda.gov/animal_health/nahms/feedlot/downloads/feedlot2011/Feed11_dr_PartI_1.pdf

USDA:NASS 2017. Inventory of beef cows. Retrieved from https://quickstats.nass.usda.gov/

USDA:NASS 2021. Cattle-Calf crop. Retrieved from https://quickstats.nass.usda.gov/

Verteramo Chiu L, Tauer L, Kaniyamattam K, Lhermie G and Gröhn Y 2022. Benefits of preconditioning cattle under stochastic feedlot performance. *Journal of Agricultural and Applied Economics* **54**(4), 656–673. https://doi.org/10.1017/aae.2022.32

Wang HH, Wang Y and Delgado MS 2014. The transition to modern agriculture: Contract farming in developing economies. *American Journal of Agricultural Economics* **96**(5), 1257–1271. https://doi.org/10.1093/ajae/aau036

Weaber RL and Lusk JL 2010. The economic value of improvements in beef tenderness by genetic marker selection. *American Journal of Agricultural Economics* **92**(5), 1456–1471. https://doi.org/10.1093/ajae/aaq062

Williams GS, Raper KC, DeVuyst EA, Peel D and McKinney D 2012. Determinants of price differentials in Oklahoma value-added feeder cattle auctions. *Journal of Agricultural and Resource Economics* **37**(1), 114–127. http://www.jstor.org/stable/23243052

https://doi.org/10.1017/age.2025.10

Zimmerman LC 2010. Factors influencing the price of value-added calves at superior livestock auction. *MS thesis, Kansas State University*. https://krex.k-state.edu/handle/2097/6991

Zimmerman LC, Schroeder TC, Dhuyvetter KC, Olson KC, Stokka GL, Seeger JT and Grotelueschen DM 2012. The effect of value-added management on calf prices at superior livestock auction video markets. Journal of Agricultural and Resource Economics, 37(1), 128–143. https://www.jstor.org/stable/23243053

Cite this article: Verteramo Chiu, L.J., L. W. Tauer, and Y. T. Grohn. 2025. "Optimal contract design under asymmetric information to incentivize preconditioning calves for feedlots." *Agricultural and Resource Economics Review*. https://doi.org/10.1017/age.2025.10