Eliminating Arrival Antibiotic Treatment Economic Impacts on US Feedlots

DRAFT: Not for Citation without Author Permission

Elliott J. Dennis
Kansas State University
Department of Agricultural Economics
Graduate Research Assistant
grapple5@ksu.edu

Ted C. Schroeder
Kansas State University
Department of Agricultural Economics
University Distinguished Professor
tcs@ksu.edu

David G. Renter
Kansas State University
Department of Veterinary Science
Professor
drenter@vet.ksu.edu

Selected Paper prepared for presentation for the 2016 Agricultural & Applied Economics Association and Western Agricultural Economics Association Annual Meeting, Boston, MA, July 31 – August 2

Eliminating Arrival Antibiotic Treatment Economic Impacts on US Feedlots

Abstract

Bovine respiratory disease complex (BRDC) is one of the costliest ailments in cattle feeding. Often cattle do not manifest symptoms until 15 to 20 days on feed. BRDC causes reduced feeding efficiency, lower average daily gain, and sub packing plant characteristics. A preventative intervention for high risk cattle is metaphylaxis, otherwise known as mass medication. While mass treatment of high risk cattle lowers death loss, net return and return risk impacts of alternative animal health treatment strategies have not been adequately quantified. This studies estimates the net feeding returns under different health strategies and risk category for cattle fed from 1989 to 2008 and 2014 – 2015 comprising over 42,000 observations. Monte Carlo simulations and net return feeding equations were used to develop net return distributions under baseline scenarios. Results suggest that removal of mass medication greatly increases the variation in feeding returns between risk categories. There are clear trade-offs between cattle risk category and health management practice. As public scrutiny of antibiotic use in feedlots continues to grow, a body of research needs to be developed assessing the economic and societal welfare impacts of eliminating arrival metaphylaxis in US feedlots.

Keywords: cattle, Monte Carlo, antibiotic, Bovine Respiratory Disease, net returns, simulation

JEL Classification: C15, C34, G11, Q11, Q13

Introduction

Bovine respiratory disease complex (BRDC) costs the beef industry an estimated $4 billion annually and harms the health and well-being of millions of cattle. Despite advances in disease interventions, long-term sustainability of beef producers is threatened by economic impacts of BRDC. One common BRDC intervention is metaphylaxis (the administration of antibiotics to an entire pen of cattle when they arrive at backgrounding and/or feedlot facilities). The efficacy of metaphylaxis to reduce cattle health risks, and subsequently have positive impacts on production risk, cattle performance and carcass characteristics, has been well documented (Nickell et al., 2010). However, use of antibiotics in cattle production, especially mass routine treatment of animals, is facing immense public scrutiny and becoming more regulated and could potentially be prohibited in the future. Essential in assessing the regulation of antibiotic use in feedlot facilities to manage BRDC is estimating the net return and return risk impacts under various cattle feeding health management scenarios.

Public concern over the misuse of antibiotics in feedlots, antibiotic resistant bacteria, and antibiotic residuals in meat has risen steadily. While most consumers agree that treating sick animals is acceptable, the extent and type of antibiotics to administer is where opinions diverge. Consumer concerns stem from possible threats to (1) public health, (2) allergies to antimicrobial residue, and (3) maximum residue levels. Some public outcry has called for the removal of all antibiotics administered to animals without the express knowledge of a pathogen present. On the other hand, cattle producers are concerned that removing a heavily relied upon animal health option could be detrimental to animal health and result in significant animal losses and reduced profitability. Properly specifying the death loss of feeder cattle and its associated impact on cattle feeding returns can determine how regulation of metaphylaxis would affect the US cattle industry. This information is essential for producers as they continue to assess animal health interventions as well as for policy makers evaluating alternative antibiotic use policies.

Net return and return risk impacts of alternative animal health treatment strategies have not been adequately quantified. The better we can predict animal health, quantify uncertainty, and determine net return distributional impacts of antibiotic use in cattle production, the more informed policy options become surrounding antibiotic use. This study was designed to address this informational need. The results provide net returns and return risk impacts for differing BRDC risk profile cattle and health interventions. Optimal cattle feeding scenarios are assessed to determine how the US fed and feeder cattle industry would change under different policy initiatives. This study estimates the differences in net returns of cattle feeding under different health management strategies. By incorporating health management information, we are able to estimate returns and volatility of cattle feeding. Using these estimates, we draw inferences about how feeding distributions change across animal cohorts. We estimate the cost of removing mass treatment upon arrival at feedlots to at-risk cattle to the US beef industry.

Information from this paper is necessary to better understand how a change in antibiotic regulation could impact the US cattle feeding industry. Our results indicate that significantly different and higher variability in cattle feeding returns is associated with removal of mass antibiotic treatment upon arrival across the majority of cattle risk profiles.

Background

BRDC syndrome is complex and interacts between the host, environment, and the pathogen. The economic costs associated with BRD include treatment of diseased animals, death loss, lower animal performance parameters, and reduced carcass quality; hence, the frequency and impacts of BRDC make it one of the most important clinically active diseases in the US cattle industry.

Many disease management strategies for feeder cattle are implemented to manage BRDC and ultimately lower mortality and morbidity among susceptible cattle. Factors affecting BRDC risk include: placement weight, gender, season, weather characteristics, region of origin, precondition factors, vaccination strategy, and animal stress associated with distance and time in transit among others. Numerous pharmaceutical and biological products have been developed to treat BRDC with varying success in morbidity and mortality; however, success of these health strategies are directly tied to the expected incidence BRDC rate in the cattle cohort. Heterogeneity in cattle further confound the prediction accuracy of whether a cattle population will become sick. Furthermore, optimal interventions depend on the distributional probability rather than the commonly used mean.

In order to prevent the high costs associated with morbidity and mortality, vaccination and mass treatment, are applied to cattle cohorts upon arrival at the feedlot. Nearly 94% of cattle are vaccinated for one or more BRDC pathogens but generally only “high risk” cattle are mass medicated. Numerous research document that efficacy of mass treatment of cattle with reducing mortality and morbidity along with increased cattle performance. However, these populations were controlled experiment designs with relatively homogenous study populations. These outcomes may not hold if heterogeneity exists among cattle cohorts.

While there is rarely consistency among feedlot health management practices, studies indicate that feedlot health management decisions are often made despite insufficient pre-feedlot data to accurately differentiate between at-risk feeder cattle populations. This makes it challenging to accurately estimate health costs for feeder cattle with information on their previous health and management as well as their current health status. Although for a given cohort of cattle there are several factors which are known at the time the animals are purchased and placed on feed. The factors of animal purchase weight, gender, feeding location, and season of placement can be used to simulate expected cattle feeding returns and return variability.

Determining whether a given cohort of animals should receive treatment upon arrival requires a trade-off between death loss and medication costs. Each pen of cattle has a given set of inherent characteristics such as placement weight, gender, location, season, vaccination history, and breed. These characteristics coupled with managerial decisions of procurement strategy and handling define a death loss distribution. Each time a producer makes a purchasing decision they inherently assume a death loss distribution and randomly sample from it. It is common practice among producers that when a cohort of cattle arrives they "pencil in" a death loss. The producer estimation is an expected death loss that they then use to make further managerial decisions which they believe will reduce death loss. For high-risk cattle, mass treatment is prescribed. Thus, the expected value of death loss is the main driver of vaccination and treatment decisions to manage BRDC incidences.

Many studies have shown that an increase in incidence of BRDC decreases net returns per head. When making inference about the decreased net returns, no studies account for the distribution of returns. Brooks et al. (2011) compared the net returns for 337 Oklahoma fed heifers during the backgrounding and finishing based on BRDC treatment occurrence. Net returns were negative for all treatment groups within finishing and backgrounding phases. Snowder et al. (2007) examined 18,112 calves from 9 breeds over a 15-year period. Lower gains and feed conversion were present in cattle with BRDC. The reduction in cattle performance associated with BRDC resulted in a $13.90 reduction in net return per head. Schneider et al. (2009) obtained health records for 5,976 animals from Midwestern feedlots. They likewise found decreases in average daily gain and reduction in carcass grading characteristics of hot carcass weight and marbling. These decreases in slaughter characteristics resulting from one through three BRDC treatments was a decline of $23.23, $30.15, and $54.01, respectively.

Important to modeling the effects of BRDC in US cattle feeding operations is incorporating the complete net return distribution. Our study assesses the impacts of the BRDC on cattle feeding operations net returns under different health management scenarios. The intent of this analysis is to better inform policy makers and producers on the economic impacts of removing mass medication to different risk-profile cattle upon arrival using distributional net returns. To our knowledge, this study is the first to holistically examine both the producer and the national effects of said policy.

Empirical Model

The market for cattle placed on feed can be characterized by the decision of cow-calf and stocker operators and feedlot managers. Cow-calf and stocker operations supply cattle, generally ranging from 450 to 850 pounds, to feedlot managers who then feed the cattle to slaughter weight, around 1350 pounds. Demand for cattle placed on feed is derived from a feedlot's profit maximizing decision; thus, *ex ante* cattle feeding net returns (π) can be defined as:

(1) $\pi = TR - FDRC - YC - FC - HC - IC$

where *TR* is the expected total revenue per head from cattle sales, *FDRC* is the cost per head of purchasing feeder cattle, *YC* is expected average per head fixed cost (yardage cost) of feeding cattle, *FC* is the expected feed cost per head, *HC* is the expected head costs associated with animal health care, and *IC* is an anticipated interest cost. All variables are estimated on a per head basis after adjusting for shrink, mortality, and culling.

At the time a cohort of cattle is placed on feed, only the animal purchase characteristics and the associated delivery costs (*FDRC)* are known, all the rest of the profit equation determinants are unknown. Purchasing characteristics include purchase weight, gender, precondition, origin, and season. Of these, purchase weight, gender, and season are well known whereas precondition and location are generally confounded. These cohort entry characteristics impact all other feedlot profit determinants. *TR* can be estimated as the live cattle futures contract expiring near harvest date (*FP)* multiplied by the expected finished animal weight (*CSW*), adjusted for mortality (*MORT*), shrink (*SHRINK*), and culling (*CULL*) as:

(2) $TR = FP * CSW * (1 - MORT - CULL) * (1 - SHRINK) + (CULL * CULLW * CULLP)$

CSW is conditional upon animal health risks and defined as:

(3) $CSW = CPW + (ADG * DOF)$

where *CPW* is the weight of the cattle purchased by the feedlot, *ADG* is average daily weight gain while on feed, and *DOF* are the number of days on feed. In our estimation we assume *CPW* is predetermined by the producer. We estimate stochastic *ADG* as:

(4) $ADG = \beta_0 + \beta_1 * CPW + \beta_2 * SEX + \beta_3 * MORT + \beta_4 * QT2 + \beta_5 * QT3 + \beta_6 * QT4 + \varepsilon$

where *CSW* is as previously defined, *SEX* is a binary dummy variable 1 for steer, *MORT* is a percentage death loss, *QT2*, *QT3*, and *QT4* are quarterly dummy variables, and ε are random white noise residuals. Using this estimation, we are able to concurrently model the expected value and variance of *ADG*. Using the estimated coefficients from Equation 4, we obtain a fixed fitted value. Then, using the distribution of the residuals we randomly sample a residual value and add the value to the residual. This is repeated *n* times until a distribution for *ADG* is created and subsequently used in the net profit equation. Estimates for *MORT* and *CULL* condition the final weight of the animal. *MORT* represents death loss sampled from a distribution of mortality rates directly attributed to BRD infection which a feedlot faces given the purchased cattle cohort characteristics. Veterinary expert opinion supplemented with empirical feedlot data suggest that

MORT follows a log normal distribution truncated at zero. Depending upon health interventions and cattle characteristics, the center of the distribution is shifted and the extreme value (i.e. worst case scenario) changes. High risk cattle, with cattle weight used as the proxy is an indicator of immunity development, with no medical intervention represent the most extreme death loss whereas low risk with medical intervention represent the lower bound. *CULL* represents animals that are considered chronically ill or not performing in the feedlot which are removed and marketed separately from the remaining cohort. Allowance is made in the total revenue calculation for culled animals by the probability of being culled (*CULL*) multiplied by the carcass weight (*CULLW*) times the net weight price adjusted for transportation (*CULLP*). *CULLP* is an USDA carcass cutout value, *CULLW* and *CULL* are assumed to be fixed at 532 pounds carcass weight and 1.4%, respectively. *YC* represents the sum total of cattle head days for a given cohort multiplied by a set daily fee per head. *FC* in Equation 5 is defined as:

(5) $FC = FEEDPRICE * CONV * ADG * DOF$

where *FEEDPRICE* is the expected price of feed using the nearby corn futures at the time cattle are placed on feed. *FEEDPRICE* is multiplied by the stochastically estimated *ADG* and implied *DOF*. Since *CONV* is conditional upon animal health it is estimated as:

(6) $CONV = \gamma_0 + \gamma_1 * CPW + \gamma_2 * SEX + \gamma_3 * MORT + \gamma_4 * QT2 + \gamma_5 * QT3 + \gamma_6 * QT4 + \varepsilon$

Where all variables definitions are the same as Equation 4. As *ADG* and *CONV* likely related, sampling randomly from the residual distribution and adding it to a fixed fitted *CONV* value will, at times, yield impractical results. To account for interrelationship between *ADG* and *CONV* we take the matrix correlation and decompose it using the Cholesky decomposition method. Using the decomposed matrix *C* we multiply a matrix of the previously estimated *ADG* and *CONV* residuals. Doing so maintains the original values of *ADG* while adjusting the *CONV* residuals to accounting for the correlation. These correlation-adjusted *CONV* residuals are then added to the estimated fixed *CONV* element. Expected *IC* in Equation 1 is calculated as a fixed interest rate times the entire cost of feeder animal and one-half of the remaining expected costs as in standard in cattle feeding budgets. Finally, health costs *HC* are econometrically estimated in similar fashion to *ADG* and *CONV* as follows:

(7) $HC = \alpha_0 + \alpha_1 * CPW + \alpha_2 * SEX + \alpha_3 * MORT + \alpha_4 * META + \varepsilon$

Where HC are dollars per head of medication and other associated handling and health management costs. Two modifications are made over other estimated models. *META*, a dummy variable, is included to capture the increased health costs associated with mass treating animals upon arrival at the feedlot, one for mass medicated and zero otherwise. Empirical distributions support the inclusion of the variable as an additional fixed cost medication cost is added to other animal health costs when mass medication is given as demonstrated by a bimodal distribution of veterinary costs. Second, quarterly dummies are dropped due to insufficient data to model true seasonality which occurs over differing cattle cycles.

Simulation

The economic model described was used to estimate changes in expected return distributions based upon factors associated with disease management. Cattle were first classified into one of six categories: high, medium or low risk and mass treatment or no treatment. In practice, cattle cohorts are classified loosely into “risk” categories based on veterinary advice, previous experience, transportation, and cattle characteristics. Feedlot managers then make decisions on appropriate profit maximizing health interventions such as mass antibiotic treatment. As a general rule of thumb, cattle placement weight is used as a proxy for cattle risk. Lighter cattle, generally 450-550 pounds, are generally more susceptible to disease and thus higher risk. Historically, these cattle more often than not receive mass medication. Heavier cattle 800 plus pounds are generally yearlings which have stronger immune systems; hence, these cattle are deemed low risk and rarely given mass treatment. Medium risk cattle, 600-750 pounds, are highly volatile and are generally where feedlot operators diverge in their consensus on what health management strategy should be pursued. Whether cattle are given mass treatment upon arrival is highly subjective and is often a "case-by-case" decision. Each cattle risk and health treatment plan combination is associated with a given death loss distribution.

Baseline parameters for the economic simulation are given in Table 1. Given the cattle cohort risk-health treatment scenario, the simulation net profits were calibrated. This was done in two steps. First the median death loss was selected for the given risk-health management scenario. This step was preemptively taken to ensure that death loss as not skewed. Second, feeder cattle futures prices were adjusted so that the net returns across all scenarios were centered on zero so they could be easily compared across placement weight. Using the base scenarios from Table 1, a baseline net return distribution was generated across all scenarios. Next, we allowed death loss to vary using Monte Carlo simulation and randomly selected from the associated death loss distribution to calculate a net return distribution, and then took the mean. This process was done iteratively 10,000 times until distributional convergence was achieved. This method allows for *ex ante* returns to be conditioned based on health interventions and characteristics of different at-risk populations of feeder cattle.

By generating these distributions through multiple scenarios we can compare and quantify the expected return distributions to animal health factors and management interventions. The expected net returns enable us to calculate an upper estimation of industry costs for given animal health policies. It also allows for the selection of optimal health management practices for a given cohort of cattle. Lastly, this will help us determine the relationships between pre-feedlot source and management attributes, feedlot management, demographic characteristics of cattle cohort, feedlot demographics, and industry markets.

Data

Data for the simulation comes from ten feedlot company proprietary databases for operations located in Midwestern states. The data ranged from 1988 to 2008 and 2014 to 2015. The first time period was used as it represents over 42,000 cohorts of cattle over multiple cattle cycles and where cattle prices were relatively stable; thus, robust estimates of seasonality and death loss over a wide range of cattle could be captured. The second period was used to capture of the effect of health interventions. Refined health intervention data was not available in the first period. While this data represents a much smaller amount of cohorts, 2,200 initially, cross checking cattle performance parameters against the larger dataset indicates data robustness in the variables of interest. A cattle cohort was defined as animal groups that were similarly purchased, assembled, and managed during a feeding period. Inclusion of cohorts was conditional upon completeness of performance parameters that were biologically feasible. Total remaining cohorts included 41,762 accounting for 5,210,514 cattle marketed. A summary of the performance parameters are given in Tables 2 and 3. Of the cohorts used, over half received mass treatment upon arrival. The case definition used to determine whether animals were mass treated or not was if a given cohort was given one of currently FDA approved drugs available and prescribed by a veterinarian. Case definition for risk category were the same across treatment groups and were as follows: high ~ 550 lbs., medium ~ 700 lbs., and low ~ 850 lbs.

Results

Table 4 reports the results from the econometric estimation of *ADG*, *CONV*, and *HC*. Steers which are placed on feed have higher daily gains and an increase in mortality decreases daily gains of the cohort in the *ADG* estimation. As cattle become sick, less feed is consumed and the feed that is consumed is used for body weight maintenance. For *CONV* estimation, an increase in conversion (i.e., less efficient or more pounds of feed per pound of gain) is associated with an increase in mortality. Estimation for *HC* demonstrates that for a given cohort of cattle, in our sample, a base cost of $14 per head was typical. If mass antibiotic treatment was used an additional fixed $23 per head treatment cost was assumed. Mortality is also economically significant as an increase in mortality was associated with an increase in health costs demonstrating feedlot operators attempt to therapeutically treat animals before death occurs. Placement weight and gender were not significant most likely due to small sample size historically steers are more likely to have higher health costs while higher placement weights are associated with a decrease in health costs.

The simulations under the different scenarios are reported in Figure 1 at the break-even feeder cattle prices. First examining the use of mass treatment. Higher risk cattle have larger variation in net returns due to a higher probability of mortality. For high risk cattle under no mass medication costs net feeding returns are much flatter and dispersed. Similarly, high and medium risk cattle net returns are flatter with longer tails demonstrating that negative returns are more likely. Comparing mass treatment vs. no treatment indicates that using mass treatment upon arrival lowers variation in cattle feeding net returns. Furthermore, higher medication costs lower death loss enough to cover higher medication costs. In similar fashion, it lowers the variation in all risk categories.

In order to confirm whether these means were statistically different from each other, we estimate a factorial ANOVA with risk category and health treatments as factors and net returns being the response. Interaction plots indicate High and Medium risk categories means differ from each other. Low risk cattle under mass treatment or no treatment do not differ from each other. Post-hoc Tukey HSD test was performed to determine whether all interaction combinations differed significantly from each other. Results indicate in Table 5 that both treatment and risk category means are significantly different from each other. Mean interactions between each risk class factor and health treatment factor suggest all mean interactions are significantly different from each other ($p < 0.01$). This confirms previous net return plots that feedlot producers should be indifferent about with respect to net returns between these two groupings of cattle. It further illustrates the trade-offs feedlot managers face and why mass treatment is so commonly accepted. If producers are able to secure higher margins with lower perceived risk using mass medication, then exposing his/her operation to a disease outbreak. There are clear trade-offs between cattle risk category and health management practice.

Conclusions

This study determined the effects to the cattle feeding industry if mass medication was banned from feedlots for at-risk cattle upon arrival. Using proprietary feedlot data from 1989 to 2008 and 2014 to 2015 and over 42,000 observations we determine that returns are more variable for cattle which are not treated upon arrival than those who are. While higher medication costs exist, over $23 in our data sample, decreases in death loss compensate for high medication costs. Likewise, nearly all mean returns are statistically different from each other ($p < 0.01$). Given the choice between a different risk categories and treatment strategies feedlot producers profit maximize by mass medicating low and medium risk cattle and not medicating other separate low risk cattle. Together these risk-treatment categories account for over 94% of all cattle feedlots should source to optimize profits, which under our base scenarios are slightly less than break-even.

The better we can predict animal health, quantify uncertainty, and determine net return distributional impacts of use of antibiotics in cattle production, the more informed policy options become surrounding antibiotic use. As public scrutiny of antibiotic use in feedlots continues to grow a body of research needs to be developed assessing the economic and societal welfare impacts of eliminating arrival metaphylaxis in US feedlots. Defining what these welfare and explicit distributions are will then enable producers and policy makers to make informed decisions surrounding the complete removal of mass medication upon arrival and its associated impact upon the cattle feeding industry.

References

Brooks, Kathleen Rae, Kellie Curry Raper, Clement E. Ward, Ben Patrick Holland, Clinton R. Krehbiel, and Douglas L. Step. "Economic effects of bovine respiratory disease on feedlot cattle during backgrounding and finishing phases." *The Professional Animal Scientist* 27, no. 3 (2011): 195-203.

Nickell, Jason S., and Brad J. White. "Metaphylactic antimicrobial therapy for bovine respiratory disease in stocker and feedlot cattle." *Veterinary Clinics of North America: Food Animal Practice* 26, no. 2 (2010): 285-301.

Schneider, M. J., R. G. Tait, W. D. Busby, and J. M. Reecy. "An evaluation of bovine respiratory disease complex in feedlot cattle: Impact on performance and carcass traits using treatment records and lung lesion scores." *Journal of animal science* 87, no. 5 (2009): 1821-1827.

Snowder, G. D., L. Dale Van Vleck, L. V. Cundiff, and G. L. Bennett. "Bovine respiratory disease in feedlot cattle: environmental, genetic, and economic factors." *Journal of Animal Science* 84, no. 8 (2006): 1999-2008.

Figures

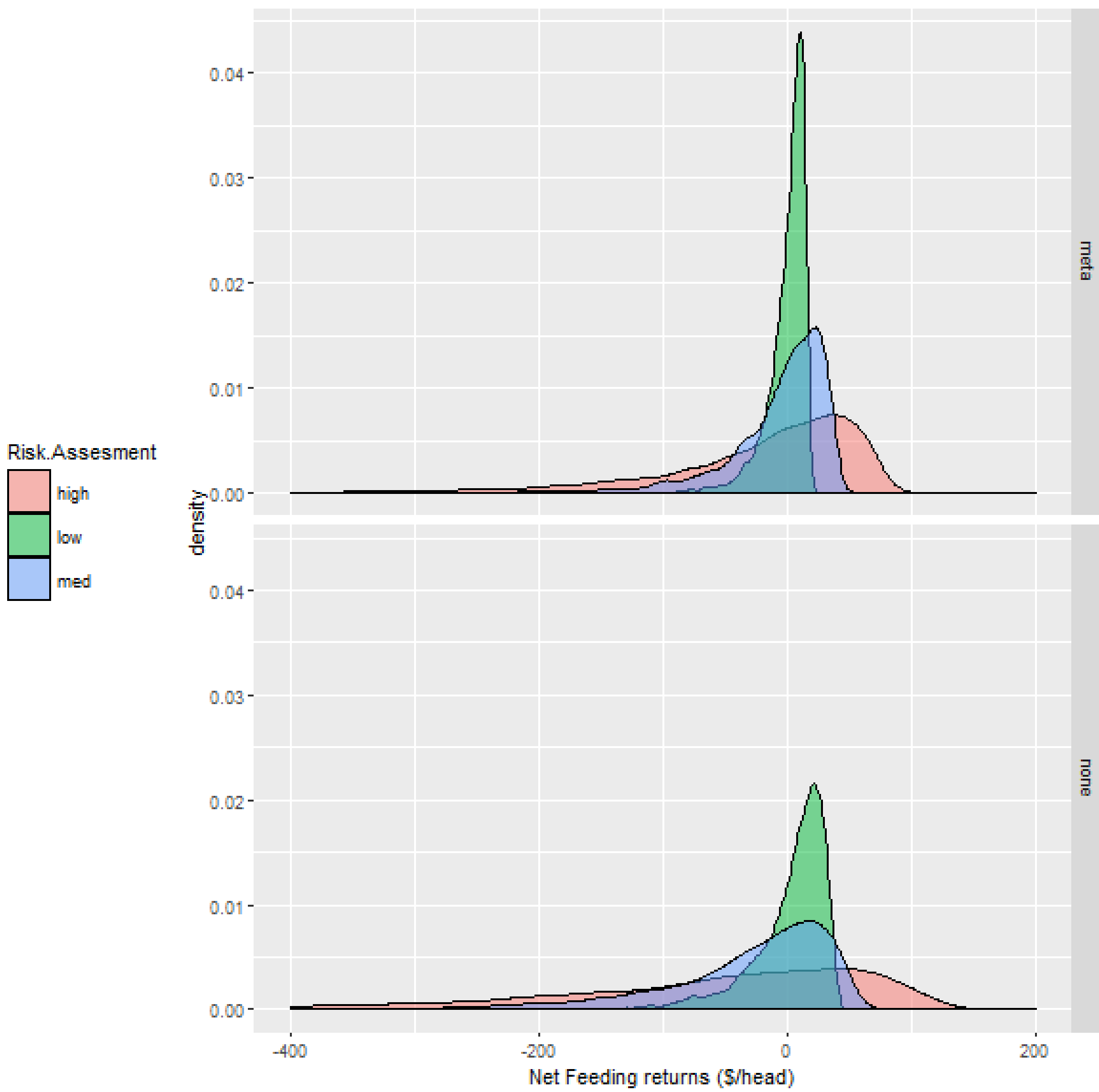

Figure 1. Net returns for cattle feeding under different health management scenarios

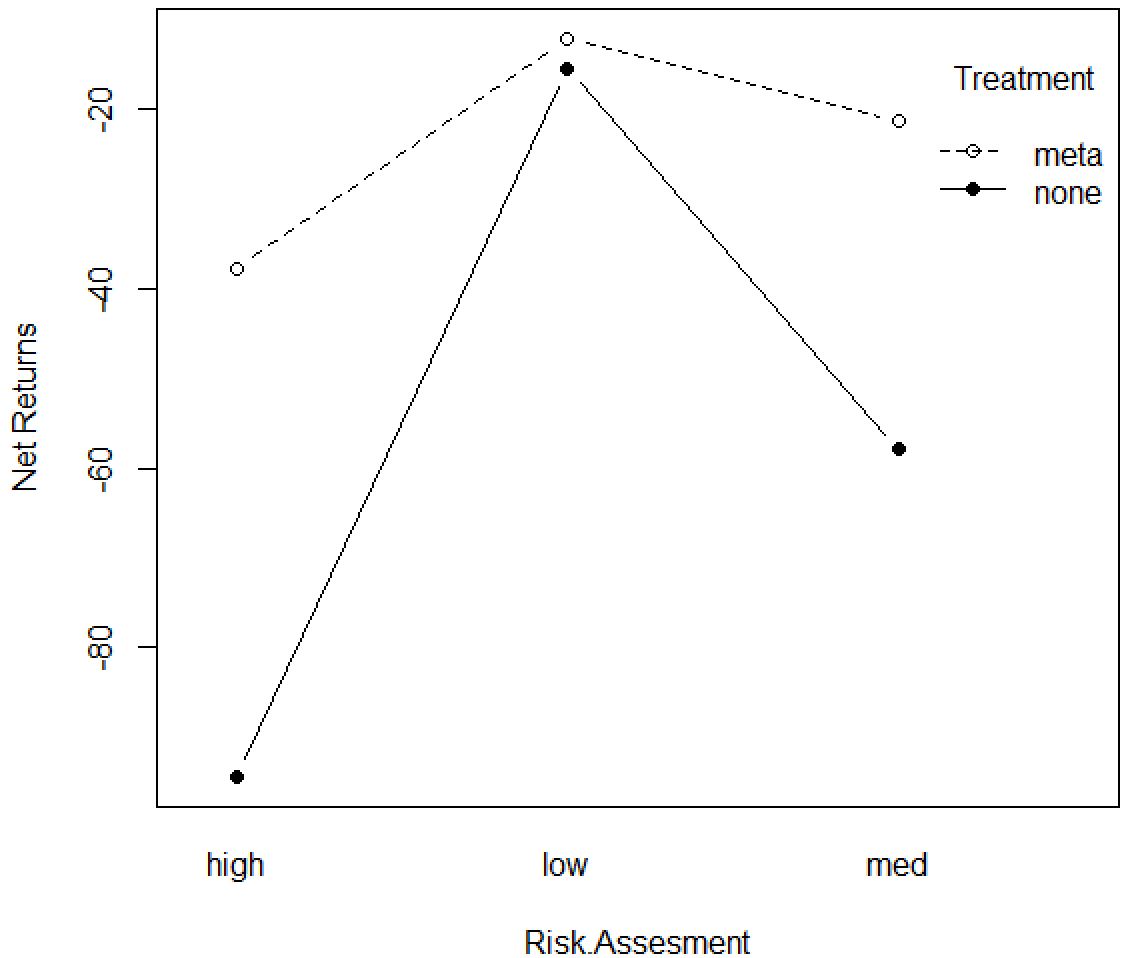

Figure 2. Interaction plot of net returns for different health management scenarios

Tables

Table 1. Summary of Base Scenarios used for Net Return Simulation

Risk	Treat[a]	Gender	Season	In-weight[b]	Mortality[c]	Feeder Cattle[d]
Low	yes	Steer	Spring	850	1	107.5
Medium	yes	Steer	Spring	700	2.5	114.5
High	yes	Steer	Spring	550	5	122
Low	no	Steer	Spring	850	2	107.75
Medium	no	Steer	Spring	700	5	111.5
High	no	Steer	Spring	550	10	114.25

Note: a) whether mass treatment was given; b) in pounds; c) percentage; d) dollars per cwt

Table 2. Summary Statistics for 1989 to 2008

Statistic	N	Mean	St. Dev.	Min	Max
Feed conversion (lbs to gain)	40,398	6.024	0.574	4.010	8.980
Daily gain (lbs / day)	40,398	2.928	0.563	1.501	4.997
Mortality (%)	40,398	1.315	1.833	0.000	48.128
Placement weight (lbs)	40,398	675.912	131.856	271.270	1,438.250
Health costs ($ / head)	40,398	5.271	7.065	0.000	58.243

Table 3. Summary Statistics for 2014 to 2015

Statistic	N	Mean	St. Dev.	Min	Max
Daily gain (lbs / day)	1,364	3.438	0.478	1.532	4.970
Mortality (%)	1,364	2.623	3.415	0.000	33.898
Placement weight (lbs)	1,364	702.345	183.874	249.740	1,401.059
Health Costs ($ / head)	1,364	26.944	15.987	1.256	110.605

Table 4. Regression Estimation Results

	Daily Gain	Feed Conversion	Health Costs
Mortality	-0.052***	0.022***	0.993***
	(0.001)	(0.001)	(0.085)
Placement Weight	0.002***	0.002***	0.001
	(0.00002)	(0.00002)	(0.002)
Gender	0.275***	-0.245***	0.743
	(0.004)	(0.006)	(0.486)
Spring	-0.022***	0.076***	
	(0.006)	(0.007)	
Summer	-0.080***	0.310***	
	(0.006)	(0.007)	
Fall	-0.147***	0.274***	
	(0.006)	(0.008)	
Mass Treatment			23.481***
			(0.743)
Constant	1.539***	4.569***	14.507***
	(0.013)	(0.017)	(1.570)
Observations	40,398	40,398	1,364
Adjusted R^2	0.513	0.182	0.689

Note: *p<0.1; **p<0.05; ***p<0.01