EFFECTS OF JOINT PRODUCT MANAGEMENT STRATEGIES ON E. COLI 0157:H7 AND FEEDLOT PROFITS

by

William R. Perry, Thomas Marsh, Rodney Jones, M.W. Sanderson, and J.M. Sargeant: Kansas State University; D.D. Griffin: University of Nebraska; and R.A. Smith: Oklahoma State University

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ABSTRACT

The objective of this study was to determine the effect of Escherichia coli 0157:H7 on feedlot profits. Fecal samples from 711 feedlot pens in 73 feedlots in Nebraska, Kansas, Oklahoma, and Texas were tested for E. coli 0157:H7. Average daily gain and feed-to-gain ratios were computed for each feedlot pen, and managers from each feedlot provided information on various feedlot management practices. Cattle performance and E. coli 0157:H7 prevalence are both affected by feedlot management practices. The indirect effect of E. coli 0157:H7 on potential feedlot profits was determined by measuring the effects of management practices on E. coli 0157:H7 levels and cattle performance.

Management practices that affect cattle performance were identified using ordinary least squares regressions. A negative binomial regression was used to identify management practices that affect E. coli 0157:H7 prevalence. Certain feedlot management practices were identified that have a joint impact on cattle performance and E. coli 0157:H7 prevalence. Using predatory insects to control flies, controlling for stray dogs, foxes, and coyotes in feed areas, removing manure from pens during finishing, and including tallow in the ration were management strategies associated with higher feedlot profits and lower E. coli 0157:H7 prevalence. Using mobile sprinklers for dust control and including alfalfa or sorghum hay or silage in the ration were associated with lower E. coli 0157:H7 prevalence and lower feedlot profits. Increasing days between cleaning water tanks and restricting movement of horses were associated with higher feedlot profits and higher E. coli 0157:H7 levels. Controlling for stray cats in feed areas and including liquid protein in the ration were associated with lower feedlot profits and higher E. coli 0157:H7 levels.

These specific management strategies, which were not robust through a sensitivity analysis, should be interpreted with caution. The general categories of management strategies, however, were robust and consistent with past research

INTRODUCTION

Throughout the last decade, public concern in food-borne diseases has increased significantly (Piggott and Marsh). A leading cause for this trend has been outbreaks of human illnesses that have been tied to food-borne pathogens. Escherichia coli 0157:H7 (hereafter E. coli 0157:H7) is one of the most well known of such pathogens. E. coli 0157:H7 is a bacteria, that when ingested, can cause serious human illness. Common illnesses include bloody diarrhea, hemolytic uremic syndrome, and hemorrhagic colitis (Hancock et al., 1997 C; Shere, Bartlett, and Kaspar). E. coli 0157:H7 has been estimated to cause over 70,000 illnesses and 60 deaths annually in the United States (Mead et al.).

Cattle have been identified as a source for E. coli 0157:H7, and as a vehicle for transmitting the bacteria to humans (Armstrong, Hollingsworth, and Morris; Chapman et al.). Much research has been conducted concerning prevalence and possible causes of E. coli 0157:H7 in feedlots. Likewise, numerous studies have examined the determinants of feedlot profitability. However, little empirical research has been done concerning the joint relationship between E. coli 0157:H7 and feedlot profits. As feedlot owners look into the future, there appear to be more and more reasons for concern about E. coli 0157:H7 prevalence. Policy initiatives like country of origin labeling indicate that some form of a mandatory identification system will eventually be introduced to the U.S. beef industry. Accountability for beef characteristics, including bacteria contamination, may be defined in contracts between buyers and sellers at all levels of the industry. It is likely that all segments of the beef industry, including feedlots, will bear some food safety responsibilities.

Feedlot owners will be faced with the challenge of reducing the risk of meat contamination, and thus of managing E. coli 0157:H7 prevalence at the feedlot. Knowledge of how management practices influence E. coli 0157:H7 prevalence is important. As is the case with management of all "pest" type organisms, there exists interest in defining more efficient levels of E. coli 0157:H7 control (Marsh, Huffaker, and Long). In order to make economically sound decisions about E. coli 0157:H7 management, producers must have knowledge of how E. coli 0157:H7 and profits are related.

Objective

The objective of this study is to determine the joint effect of management strategies on E. coli 0157:H7 prevalence and feedlot profits. This effect on potential feedlot profits is measured via the performance of feedlot cattle. Cattle performance, in turn, is measured by average daily gain and the feed-to-gain ratio. Previous studies suggest that the relationship between cattle performance and E. coli 0157:H7 is not a causal one (ceteris paribus, the performance of cattle with E. coli 0157:H7 is equal to that of cattle without E. coli 0157:H7), but rather an indirect relationship connected through feedlot management practices (Hancock et al., 1994; Armstrong, Hollingsworth, and Morris). In this study, feedlot cattle are treated as a biological vector by which E. coli 0157:H7 populations live and grow. Thus, feedlots are considered to jointly produce beef and E. coli 0157:H7. This bioeconomic framework is motivated by previous work from Marsh, Huffaker, and Long. As joint products, cattle performance and E. coli 0157:H7 levels are hypothesized to be affected by certain feedlot management practices.

In order to determine the impact of E. coli 0157:H7 on feedlot profits via cattle performance, management practices must be identified that affect E. coli 0157:H7 prevalence and cattle performance. The specific objectives of this study are to identify management practices that impact: 1) the performance of feedlot cattle, 2) E. coli 0157:H7 prevalence, and 3) cattle performance and E. coli 0157:H7 prevalence.

CONCEPTUAL MODEL

Feedlot profitability is dependent on the performance of the cattle in the feedlot (Langemeier, Schroeder, and Mintert; Lawrence, Wang, and Loy; Mark, Jones, and Mintert, 2002 A & B; Mark, Schroeder, and Jones; McDonald and Schroeder). Holding all else constant, average profitability increases as average daily gain increases. Likewise, costs decrease (and, hence, profitability increases) as the feed-to-gain ratio decreases (Mark, Schroeder, and Jones). Previous literature suggests management decisions impact both cattle performance and E. coli 0157:H7 prevalence (Dargatz et al.; Sargeant et al., submitted 2004; Garber et al.; Hancock et al., 1994). Thus, in order to identify the indirect relationship between E. coli 0157:H7 and feedlot profits, the model is designed to measure the joint effects of feedlot management practices on E. coli 0157:H7 prevalence and cattle performance.

Feedlot Profit Maximization

The conceptual model used in this study stems from producer supply theory, in which a feedlot is a profit maximizing firm in a competitive industry. Firm profits are a function of exogenous output prices (P), quantity produced (Q), and cost (C), which is a function of a vector of exogenous input prices (w) and quantity produced.

$$\Pi = PQ - C(w, Q)$$

In this case, the firm will chose Q in order to maximize profit. Here, Q represents pounds of beef produced and C represents the minimum cost means of producing a pound of beef.

For the vector of factor inputs (x), the optimization problem can be restated as

$$\Pi = PQ(x;V) - C(w, Q(x;V);Z)$$

where V is an exogenous vector of output shifters, such as feedlot capacity, and Z is an exogenous vector of cost shifters. In order to maximize profit, the firm will choose the level of inputs x such that the value of the marginal product ($P\frac{\partial Q}{\partial x}$) will equal marginal factor cost ($\frac{\partial C}{\partial x}$), thus satisfying the first order condition that $P\frac{\partial Q}{\partial x} - \frac{\partial C}{\partial x} = 0$.

Now, suppose that a feedlot chooses a target level $\bar{Q}$ for a pen of cattle over its planning (feeding) period. In other words, when a pen of feeder cattle is purchased, the feedlot decides how much weight the cattle must gain in order to become a saleable product. This simple interpretation of the profit maximization problem assumes the feedlot fixes revenues at $P\bar{Q}$ and operates as cost minimizer throughout the planning period. One means to achieve the target level $\bar{Q}$ is to select inputs x^{ADG} consistent with an average daily gain (ADG) value that cumulates to be greater than or equal to $\bar{Q}$ by the end of the planning period. Obviously, this approach in and of itself does not necessarily lead to a least cost approach to selecting inputs. A means to incorporate cost efficiency into achieving the target level $\bar{Q}$ is to select inputs x^{FTG} consistent with a selected feed-to-gain (FTG) ratio, which is the ratio of total pounds of feed to total pounds of gain. For instance, consider decomposing cost as

$$\text{Cost} = \left(\text{lbs of gain}\right)\left(\frac{\text{lbs of feed}}{\text{lbs of gain}}\right)\left(\frac{\$}{\text{lb of feed}}\right)$$

In practice the approach is to then select the inputs x consistent with an ADG and FTG ratio that achieves the target level of output in a least cost manner.

Under this framework, output is restricted (at least in the short run) by capacity restraints, leaving cattle performance as the driving factor behind quantity produced. Cattle performance is a variable that represents how much, and how efficiently quantity is actually produced at the feedlot. Two commonly used measures of feedlot cattle performance are the feed-to-gain ratio and average daily gain. Average daily gain is a determinant of quantity produced and the feed-to-gain ratio is a determinant of cost of production. Both average daily gain and the feed-to-gain ratio are functions of feedlot management practices and a vector of performance shifters.

Below, *ADG* is average daily gain and *FTG* is the feed-to-gain ratio

$$ADG = f_1(M1, V) \qquad\qquad FTG = f_2(M2, Z)$$

where *M1* and *M2* are vectors of feedlot management practices. The *M1* and *M2* vectors represent all management decisions that impact average daily gain and feed-to-gain respectively. Again, *V* and *Z* are exogenous shifters.

Feedlot management practices, along with a vector of prevalence shifters, determine E. coli 0157:H7 levels.

$$E = f(M3, R)$$

In the above equation, *E* represents E. coli 0157:H7 prevalence at the feedlot, *M3* is a vector of management practices, and *R* is and exogenous vector of prevalence shifters. All management practices contained in the *M1* (from Section 3.1) and *M3* vectors, or the *M2* (from Section 3.1) and *M3* vectors have joint impacts on cattle performance and E. coli 0157:H7 prevalence. These management practices represent the indirect relationship between E. coli 0157:H7 and feedlot profitability.

Downstream Production Externality

There are two types of costs associated with human E. coli 0157:H7 consumption: damage costs and control costs. The damage costs include the cost of human illness and, most likely, the cost of a beef recall (physically removing beef from retail outlets). The control cost of reducing E. coli 0157:H7 prevalence in beef can be thought of as the cost of avoiding an E. coli

0157:H7 outbreak. Because beef recalls are a voluntary action taken by processors, the physical cost of the recall is born by processors. Currently, beef processors also bear the control costs (Marsh, Schroeder, and Mintert). In order to minimize the total cost of human E. coli 0157:H7 consumption, an efficient level of E. coli 0157:H7 control must be employed. The efficient level of E. coli 0157:H7 control occurs when the marginal damage cost equals the marginal control cost.

Under the above described feedlot maximization framework, the feedlot is only concerned with maximizing its own profit independent of E. coli 0157:H7 prevalence. Currently, contracts between feedlots and processors do not involve agreements on allowable levels of E. coli 0157:H7 prevalence. In other words, feedlots will not receive a lower price for cattle shedding E. coli 0157:H7 than for cattle not shedding E. coli 0157:H7, all else equal. In maximizing profits, feedlots will employ E. coli 0157:H7 reducing management practices if those management practices also improve cattle performance because feedlots do not incur the true cost of E. coli 0157:H7 prevalence.

Now consider a two firm scenario in which the feedlot is the upstream firm and the beef processor is the downstream firm. The optimization problems are stated as

$$\Pi_U = P_U Q_U(x;V) - C_U(w, Q_U(x;V);Z)$$

$$\Pi_D = P_D Q_D(y,E;V) - C_D(m, Q_D(y,E;V),E;Z)$$

where the subscript *U* denotes the upstream firm (feedlot) as described earlier and the subscript *D* denotes the downstream firm (processor). In the downstream profit equation, *m* is a vector of exogenous input prices for factor inputs *y*, and *V* and *Z* are, again, exogenous vectors of output and cost shifters respectively. Unlike the feedlot optimization problem, the processor optimization problem includes E. coli 0157:H7 prevalence (*E*). E. coli 0157:H7 prevalence directly impacts the processor's output and costs (through E. coli 0157:H7 control practices and beef recalls). The joint profit optimization problem can be stated as

$$\Pi_{U+D} = P_U Q_U(x;V) + P_D Q_D(y,E;V) - C_U(w, Q_U(x;V);Z) - C_D(m, Q_D(y,E;V), E;Z)$$

Recall that E. coli 0157:H7 prevalence is a function of a vector of management practices (*M3*). The *M3* vector of management practices includes decisions on inputs (*x*). Thus, E. coli 0157:H7 (*E*) is a function of *x*. In this joint profit maximization problem, the feedlot chooses a level of *x* in order to maximize total profit while satisfying the first order condition that

$$P_U \frac{\partial Q_U}{\partial x} + P_D \frac{\partial Q_D}{\partial E}\frac{\partial E}{\partial x} - \frac{\partial C_U}{\partial Q_U}\frac{\partial Q_U}{\partial x} - \frac{\partial C_D}{\partial E}\frac{\partial E}{\partial x} = 0 .$$

Notice that this is a different first order condition than was satisfied under the feedlot profit maximization problem. Here, the first order condition states that the sum of the value of the marginal product ($P_U \frac{\partial Q_U}{\partial x}$) and the value of the marginal damage incurred by the downstream firm ($P_D \frac{\partial Q_D}{\partial E}\frac{\partial E}{\partial x}$) must equal the sum of the marginal cost for the upstream firm ($\frac{\partial C_U}{\partial Q_U}\frac{\partial Q_U}{\partial x}$) and the additional marginal cost from E. coli 0157:H7 for the downstream firm ($\frac{\partial C_D}{\partial E}\frac{\partial E}{\partial x}$). The fact that the feedlot satisfies a different first order condition under the feedlot maximization problem relative to the joint profit maximization problem shows that, under the feedlot maximization problem, the feedlot chooses an inefficient amount of *x*, and thus produces an inefficient amount of E. coli 0157:H7.

EMPIRICAL MODELS

The purposes of the empirical models are to measure the impact of management practices on average daily gain, feed-to-gain, and E. coli 0157:H7 prevalence. This requires three independent regressions, with average daily gain, the feed-to-gain ratio, and E. coli 0157:H7 as the dependent variables, and management practices as independent variables. The models are not specified in structural economic manner, but rather in a reduced form nature.

Management Impacts on Cattle Performance

Previous research has identified many feedlot management practices that impact the performance of feedlot cattle. As discussed earlier, average daily gain and the feed-to-gain ratio are both measures of cattle performance. The following models are specified as general linear models and are designed to identify management variables that impact average daily gain and feed-to-gain respectively.

$$ADG = X\beta_1 + \varepsilon_1$$

$$FTG = X\beta_2 + \varepsilon_2$$

In the above equations, *ADG* represent the average daily gain for a pen of feedlot cattle and *FTG* represents the feed-to-gain ratio for a pen of feedlot cattle. In each equation, *X* represents a vector of management strategies, β_i represent the parameters to be estimated, and ε_i represents random error terms.

The *X* vector represents a wide range of feedlot management practices. These practices can be grouped into categories. Feeding methods (Knoblich, Fluharty, and Loerch), water management (Willms et al.), feed management (Merchen, Berger, and Fahey; Bossuyt, Wittenberg, and Crow), wildlife management (Palmer; Lee), ration composition (Zinn et al.; Krehebiel et al.), animal stress management (Mader et al.; Wagner), animal health management (Mader; Gardner et al.), fly control (Roberts and Pund), breed selection (DeRouen et al.), and placement weight (Mark, Schroeder, and Jones) are all areas of feedlot management that have been identified in previous research as factors that affect animal performance. Previous research has also examined the effect of climate on animal performance (Hubbard et al.). Management variables from each of these categories comprise the vector of independent variables in the empirical model.

Management Impacts on E. coli 0157:H7 Prevalence

The following model is constructed to identify management practices that influence E. coli 0157:H7 prevalence. The dependent variable, μ, is the mean of the number of fecal samples testing positive for E. coli 0157:H7 in a feedlot pen. Just as in the average daily gain and feed-to-gain models, *X* represents a vector of management strategies and β represents the parameters to be estimated.

$$f(\mu) = Y + X\beta$$

The X vector in this model is comprised of the same management strategies as the X vector in the average daily gain and feed-to-gain models. Previous research has tested all management variables in this vector for associations with E. coli 0157:H7 prevalence (Sargeant et al. submitted 2004).

Econometric Estimation

Stata software was used for statistical analysis of the empirical models. Ordinary Least Squares (OLS) regression analysis was used to estimate the average daily gain and feed-to-gain models. OLS has been employed in cattle performance analysis in previous research (Lawrence, Wang, and Loy). As explained above, the dependent variable for the E. coli 0157:H7 model is the mean of the number of positive fecal samples in a feedlot pen. The number of positive fecal samples in a pen is count data, because it can only be whole numbers. In other words, there can be 1 or 2 positive fecal samples in a feedlot pen, but not 1.5 positive fecal samples. Poisson regression analysis, which uses maximum-likelihood estimation, is often used to analyze count data. In this case, the variability of the number of positive fecal samples per pen was greater than a true Poisson distribution. This greater variability is referred to as overdispersion. Negative binomial regression analysis, which also uses maximum-likelihood estimation, is often used to analyze count data that has more variability than a Poisson distribution (Cameron and Trivedi). Thus, a negative binomial regression was used to estimate the E. coli 0157:H7 model. The negative binomial specifies the log of the mean of the count variable (fecal samples testing positive for E. coli 0157:H7 in this case) as a linear function of independent variables.

DATA AND METHODS

The data used were cross sectional data obtained from a survey administered by Kansas State University College of Veterinary Medicine, with collaboration from Oklahoma State University and Great Plains Veterinary Educational Center (University of Nebraska) during the summer of 2001. The survey, which sampled 711 feedlot pens across 73 feedlots throughout Nebraska, Kansas, Oklahoma, and Texas, consisted of three sections: a pen level management section, a close out information section, and a feedlot level management section.

As part of the pen level section, fifteen fresh fecal samples were taken from each selected pen. These samples were then tested for E. coli 0157:H7. The remainder of the pen sample section consisted of information pertaining to the pen and cattle characteristics in each pen. Arrival information, health information, nutrition information, breed type, and feed and water information were obtained from feedlot managers and recorded for each pen. The close out information section includes information on pen level cattle numbers, days on feed, feed consumption, and weight gain. This information was used to calculate feed-to-gain ratios and average daily gain for each pen. The final component of the survey gathered information on the feedlot management practices. This section of the survey consisted of general feedlot information, health management practices, feed management practices, water management practices, bio-security practices and environmental management practices. This section of the survey was administered to the feedlot manager face to face by a member of the field sampling team. A list of all the model variables and their meanings as they relate to the survey is shown in Table 1.

Average daily gain was calculated by dividing the average total gain by total days on feed. Figure 1 shows the range of average daily gain across pens. This is a normal distribution with the majority of the pens having an average daily gain between 2.75 and 3.5 pounds per day. Feed-to-gain was calculated as total dry matter fed divided by the product of average number of cattle in the pen and average total gain per head. In other words, it is the ratio of the pounds of feed to the pounds of gain. Figure 2 illustrates the range of feed-to-gain ratios across pens. Aside from a low number of pens showing a feed-to-gain ratio between 6.5 and 7.0 pounds of feed per one pound of gain, this distribution follows the general shape of a normal distribution. A majority of the pens showed a feed-to-gain ratio between 5.5 and 7.5 pounds of feed per one pound of gain.

The E. coli variable is a count variable that could be a number from 0 to 15, representing the number of fecal samples testing positive for E. coli 0157:H7. Figure 3 illustrates the range of positive fecal samples across pens. The majority of the pens had no positive fecal samples. The likelihood of a pen having multiple positive samples appears to exponentially decrease as the number of positive samples increase, supporting the idea that E. coli 0157:H7 is shed transiently.

Once the observations with missing values were deleted and the data were converted from word form to numeric form, regression analysis was used to estimate the empirical models. Initially, each regression contained all management variables listed in Table 1. Insignificant variables were eliminated from each model using standard joint hypothesis testing procedures.

Figure 1 – Range of Average Daily Gain Across Pens

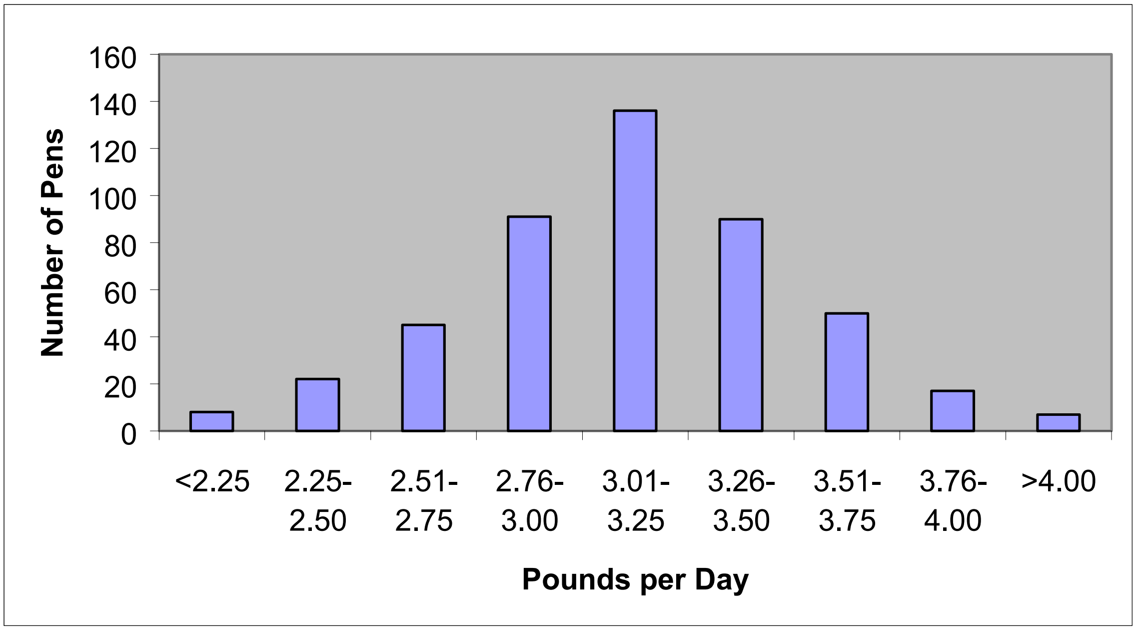

Figure 2 – Range of Feed-to-gain Across Pens

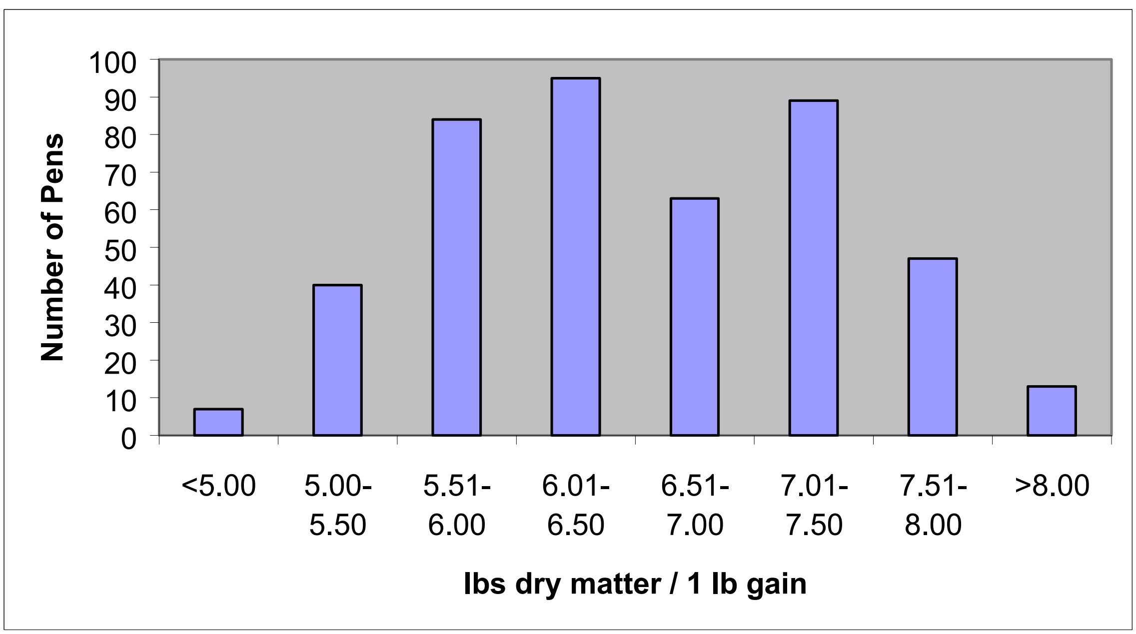

Figure 3 – Range of Positive Fecal Samples Across Pens

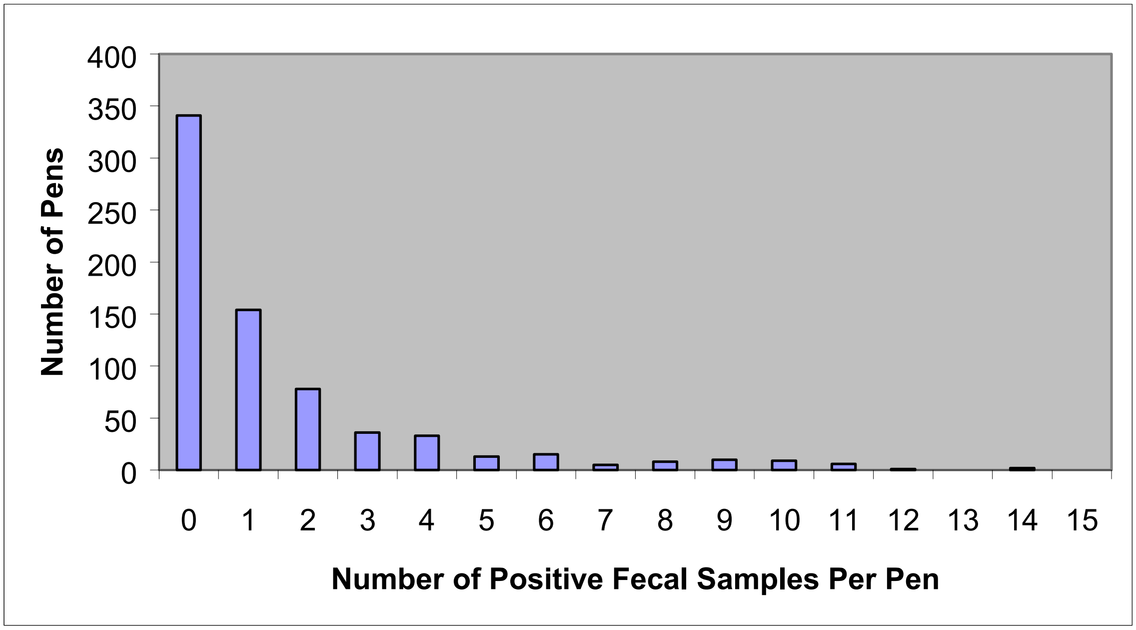

Table 1 - Model Variables

Variable	Mean	Std. Dev.	Min.	Max.	Meaning	Survey Question
adg	3.12	0.40	1.87	4.63	average daily gain	1 & 9: Close Out Section
feedgain	6.55	0.90	4.05	11.63	feed-to-gain ratio	3, 4, 5, 6, 7, & 9: Close out Section
ecoli	1.68	2.59	0	14	# of positive fecal samples per pen	Pen Level Survey (collected by samplers)
ne	0.3149	0.4649	0	1	1 if feedlot is in NE (Kansas = base), 0 if not	State: Mgmt Survey Section
ok	0.1317	0.3384	0	1	1 if feedlot is in OK (Kansas = base), 0 if not	State: Mgmt Survey Section
tx	0.1441	0.3515	0	1	1 if feedlot is in TX (Kansas = base), 0 if not	State: Mgmt Survey Section
hdinlot	50803	40135	7500	273062	# of cattle placed in feedlot in past year	1a: Mgmt Survey Section
hospmore	0.7616	0.4265	0	1	1 if always treat sick in hospital pen for 24 hours or more, 0 if sometimes or never	7a: Mgmt Survey Section
supstore	0.4982	0.5004	0	1	1 if the feedlot stores mineral supplements, feed additives, and energy concentrates in sealed bins	9a-9e: Mgmt Survey Section
haycovr	0.7473	0.4349	0	1	1 if roughage is stored in covered piles, 0 if not	9f: Mgmt Survey Section
adlib	0.0356	0.1854	0	1	1 if use ad lib feeding method (slick method = base), 0 if not	10: Mgmt Survey Section
program	0.1085	0.3113	0	1	1 if use program feeding method (slick method = base), 0 if not	10: Mgmt Survey Section
bnkscrng	0.2242	0.4174	0	1	1 if use bunk scoring feeding method (slick method = base), 0 if not	10: Mgmt Survey Section
feedings	2.5614	0.7284	2	6	feedings per day	11: Mgmt Survey Section

clnfeed	0.1459	0.3533	0	1	1 if use same machinery for feeding and cleaning pens, 0 if not	12: Mgmt Survey Section
days	7.5240	8.3811	1.5	65	days between cleaning water tanks	13: Mgmt Survey Section
empty	0.4324	0.4958	0	1	1 if clean water tanks by emptying and re-filling with fresh water, 0 if not	13: Mgmt Survey Section
scrbside	0.4964	0.5004	0	1	1 if clean water tanks by scrubbing sides with brush while full of water, 0 if not	13: Mgmt Survey Section
people	0.5587	0.4970	0	1	1 if feedlot restricts movement of people, 0 if not	14a: Mgmt Survey Section
horses	0.6263	0.4842	0	1	1 if feedlot restricts movement of horses, 0 if not	14b: Mgmt Survey Section
insect	0.4840	0.5002	0	1	1 if use predatory insects to control flies, 0 if not	15b: Mgmt Survey Section
sprays	0.7438	0.4369	0	1	1 if use sprays to control flies, 0 if not	15d: Mgmt Survey Section
pourons	0.2420	0.4287	0	1	1 if use pour-ons to control flies, 0 if not	15e: Mgmt Survey Section
flytape	0.2776	0.4482	0	1	1 if use sticky tape to control flies, 0 if not	15g: Mgmt Survey Section
flybait	0.8826	0.3222	0	1	1 if use granular fly bait to control flies, 0 if not	15h: Mgmt Survey Section
dogpenc	0.7117	0.4534	0	1	1 if feedlot controls for stray dogs, foxes, and coyotes in the pens or alleys, 0 if not	17: Mgmt Survey Section
catpenc	0.4199	0.4940	0	1	1 if feedlot controls for stray cats in pens or alleys, 0 if not	17: Mgmt Survey Section
racpenc	0.7456	0.4359	0	1	1 if feedlot controls for raccoons, skunks, etc. in pens or alleys, 0 if not	17: Mgmt Survey Section
birdc	0.6708	0.4703	0	1	1 if feedlot controls for birds in pens or alleys, 0 if not	17: Mgmt Survey Section

dogfdc	0.4893	0.5003	0	1	1 if feedlot controls for dogs, foxes, and coyotes in feed storage areas, 0 if not	19: Mgmt Survey Section
catfdc	0.4039	0.4911	0	1	1 if feedlot controls for stray cats in feed storage areas, 0 if not	19: Mgmt Survey Section
racfdc	0.5854	0.4931	0	1	1 if feedlot controls for raccoons, skunks, etc. in feed storage areas, 0 if not	19: Mgmt Survey Section
birdfdc	0.5979	0.4908	0	1	1 if feedlot controls for birds in feed storage areas, 0 if not	19: Mgmt Survey Section
sprinkle	0.1637	0.3703	0	1	1 if feedlot uses permanent sprinklers for dust control, 0 if not	20a: Mgmt Survey Section
mosprink	0.3826	0.4864	0	1	1 if feedlot uses mobile sprinklers for dust control, 0 if not	20b: Mgmt Survey Section
scrapers	0.8238	0.3813	0	1	1 if feedlot uses mechanical scrapers for dust control, 0 if not	20c: Mgmt Survey Section
morecows	0.6032	0.4897	0	1	1 if feedlot uses increased cattle density for dust control, 0 if not	20d: Mgmt Survey Section
manure	0.7758	0.4174	0	1	1 if manure is removed from the pens while cattle are finishing, 0 if not	21: Mgmt Survey Section
manurstr	0.8238	0.3813	0	1	1 if manure is stored at the feedlot, 0 if not	23a: Mgmt Survey Section
fence	0.5516	0.4978	0	1	1 if feedlot uses fencing/landscaping to manage wildlife or minimize erosion, 0 if not	24c: Mgmt Survey Section
weight	702	118	277	1049	average arrival weight of cattle in pen (pounds)	3: Pen Level Survey
onesrc	0.3737	0.4842	0	1	1 if the cattle in the were collected from a single source, 0 if not	4: Pen Level Survey
stheast	0.1815	0.3858	0	1	1 if cattle were purchased from the southeast (midwest =	5: Pen Level Survey

					base), 0 if not	
sthwest	0.2456	0.4308	0	1	1 if cattle were purchased from the southwest (midwest = base), 0 if not	5: Pen Level Survey
otharea	0.0569	0.2319	0	1	1 if cattle were purchased form an area other than the midwest, southeast, or southwest (midwest = base), 0 if not	5: Pen Level Survey
rvacresp	0.6032	0.4897	0	1	1 if cattle received re-vaccination against respiratory disease, 0 if not	6b: Pen Level Survey
vacclos	0.8025	0.3985	0	1	1 if cattle received initial vaccination against clostridial disease, 0 if not	6c: Pen Level Survey
rvacclos	0.3185	0.4663	0	1	1 if cattle received re-vaccination against clostridial disease, 0 if not	6d: Pen Level Survey
reimplnt	0.8505	0.3569	0	1	1 if cattle were re-implanted, 0 if not	6h: Pen Level Survey
massmed	0.1281	0.3345	0	1	1 if cattle were mass medicated with an injectable antibiotic, 0 if not	7: Pen Level Survey
antibio	0.4466	0.4976	0	1	1 if antibiotics were included in the ration or water, excluding ionophores and coccidiostats, 0 if not	8: Pen Level Survey
cotsdml	0.1299	0.3365	0	1	1 if cotton seed meal was in ration, 0 if not	14: Pen Level Survey
urea	0.4110	0.4925	0	1	1 if urea was in ration, 0 if not	14: Pen Level Survey
soybean	0.2972	0.4574	0	1	1 if soybean meal was in ration, 0 if not	14: Pen Level Survey
liqprot	0.4982	0.5004	0	1	1 if liquid protein was in ration, 0 if not	14: Pen Level Survey
hay	0.9039	0.2950	0	1	1 if alfalfa or sorghum hay was in ration, 0 if not	14: Pen Level Survey
silage	0.1068	0.3091	0	1	1 if alfalfa or sorghum silage was in ration, 0 if not	14: Pen Level Survey

cornsil	0.4715	0.4996	0	1	1 if corn silage was in ration, 0 if not	14: Pen Level Survey
cotsdhul	0.0765	0.2661	0	1	1 if cotton seed hulls were in ration, 0 if not	14: Pen Level Survey
cornglu	0.0979	0.2974	0	1	1 if corn gluten was in ration, 0 if not	14: Pen Level Survey
tallow	0.6406	0.4803	0	1	1 if tallow / grease was in ration, 0 if not	14: Pen Level Survey
wheat	0.1032	0.3045	0	1	1 if wheat fines / mids were in ration, 0 if not	14: Pen Level Survey
brew	0.2740	0.4464	0	1	1 if Brewer's grain / malt were in ration, 0 if not	14: Pen Level Survey
drymat	74.29	10.02	7.2	86.4	% dry matter of the ration	15: Pen Level Survey
probiot	0.3915	0.4885	0	1	1 if probiotics are used in ration, 0 if not	16: Pen Level Survey
density	314	373	18.1	4546	square feet per animal in the pen	1, 2, & 3: Pen Level Survey (collected by samplers)
contin	0.5231	0.4999	0	1	1 if primary breed was continental (british = base), 0 if not	4: Pen Level Survey (collected by samplers)
othbreed	0.0445	0.2064	0	1	1 if primary breed was not continental or british (british = base), 0 if not	4: Pen Level Survey (collected by samplers)
dry	0.7491	0.4339	0	1	1 if pen was dry, 0 if not	5: Pen Level Survey (collected by samplers)
misters	0.1050	0.3068	0	1	1 if misters were provided for cattle, 0 if not	6: Pen Level Survey (collected by samplers)
mounds	0.7117	0.4534	0	1	1 if mounds were provided for cattle, 0 if not	6: Pen Level Survey (collected by samplers)
wind	566	368	0	2000	wind velocity at time of sampling (ft. per min.)	7: Pen Level Survey (collected by samplers)

watertmp	18.4110	3.0533	8	25	water temperature 1” below surface (Celsius)	12: Pen Level Survey (collected by samplers)
bunkht	19.5569	3.5260	10	74.5	Height of feed bunk (inches)	19: Pen Level Survey (collected by samplers)
feedtemp	26.1993	9.1379	8	54	feed temperature 1” below surface (Celsius)	20: Pen Level Survey (collected by samplers)

RESULTS

There were ten management variables that significantly (P<0.05) affected both measures of cattle performance and E. coli 0157:H7 prevalence. These variables and their coefficients in each model are shown in Table 2. Of these, six were associated with improved cattle performance. Of those six variables, “insect”, “dogfdc”, “manure” and “tallow” were also associated with lower E. coli 0157:H7 prevalence. These four variables indicate that using biological fly control methods, controlling for stray dogs in feed storage areas, routinely removing manure from pens, and including tallow in the ration will have a positive effect on feedlot profits, through improved cattle performance, while lowering E. coli 0157:H7 prevalence. Two management variables (“horses” and “racfdc”) were associated with better cattle performance and higher E. coli 0157:H7 prevalence. The coefficients for these variables show that controlling the movement of horses and controlling for raccoons, skunks, and squirrels will increase average profitability but also increase E. coli 0157:H7 prevalence.

Three variables were associated with worse cattle performance. Of these, one variable (“silage”) was also associated with lower E. coli 0157:H7 levels. This indicates that including alfalfa or sorghum silage in the ration to reduce E. coli 0157:H7 prevalence would have a negative impact on average feedlot profits. Two variables (“catfdc” and “liqprot”) were associated with worse cattle performance and higher E. coli 0157:H7 prevalence. The coefficients for these variables demonstrate that controlling for cats in feed storage areas and including liquid protein in the ration will decrease feedlot profits (through worse cattle performance) and increase E. coli 0157:H7 prevalence at the feedlot. One variable (“morecows”) had positive coefficients in the average daily gain and feed-to-gain models and a negative coefficient in the E. coli 0157:H7 model. This indicates that using increased cattle density for dust control will lower E. coli 0157:H7 prevalence but will have uncertain effects on cattle performance.

Discussion

General feedlot management strategy categories, such as ration composition, wildlife management, feed and water management, and health management, each encompass several specific management strategies. For example, wildlife management is a general management category that would encompass such specific strategies as controlling for dogs in feed storage areas, controlling for stray cats in pens and alleys, and controlling for raccoons in feed storage areas.

Different methods of hypothesis testing were employed to test for the robustness of the variable elimination procedure. Both f-tests and t-tests were used for joint hypothesis testing in the average daily gain and feed-to-gain models. The results were consistent under both testing procedures. Similarly, both likelihood ratio tests and the Lagrangian Multiplier were used for joint hypothesis testing in the E. coli 0157:H7 model. Again, the results were robust across testing procedures.

In order to test the robustness of the models, a sensitivity analysis was performed in which a random ten percent of the observations in the data set were excluded. The results from the sensitivity analysis indicate that specific management variables are not robust. In other words, the specific management strategies that were significant in the three models of this thesis changed when the data were slightly altered. General management strategy categories, however, were robust throughout the sensitivity analysis. The results of the sensitivity analysis, along with findings from previous research, indicate that specific management strategies have not been identified that consistently impact E. coli 0157:H7 prevalence. On the other hand, there does appear to be some consistency in general management areas that impact both E. coli 0157:H7 and cattle performance.

Table 2 - Coefficients of Significant Variables by Model

	adg	feedgain	ecoli
horses	0.56608	-0.29976	0.66614
insect	0.42176	-0.88129	-0.83388
dogfdc	0.63278	-0.55434	-1.49116
catfdc	-0.94739	1.13780	1.85909
racfdc	0.58206	-0.39002	2.53851
morecows	0.15046	0.20863	-0.55822
manure	0.95016	-0.97590	-0.85184
liqprot	-0.88131	0.61538	1.60246
silage	-0.44891	0.63815	-1.25831
tallow	0.33374	-0.67475	-1.29574

CONCLUSION

The objective of this thesis is to determine the joint effect of management strategies on E. coli 0157:H7 and potential feedlot profits (by measuring the joint effects that management practices have on cattle performance and E. coli 0157:H7 prevalence). A conceptual model was derived from production theory in which feedlots are profit maximizing firms. The feedlot is described as a profit maximizing firm in a competitive industry that jointly produces beef and E. coli 0157:H7. The feedlot chooses a target quantity of beef in order to maximize profits, and then chooses inputs consistent with an average daily gain and feed-to-gain ratio that will achieve the target quantity in a least cost manner. In producing E. coli 0157:H7, the feedlot exerts a negative production externality upon the beef processor because E. coli 0157:H7 prevalence does not directly influence the feedlot's profit maximization decision. However, E. coli 0157:H7 may negatively impact the beef processor and lead to inefficient levels of E. coli 0157:H7 prevalence.

Three regressions were estimated using feedlot data from a large E. coli 0157:H7 prevalence, management, and performance survey. Ordinary least squares regressions were used to measure the effect of feedlot management practices on average daily gain and feed-to-gain, and a negative binomial regression was used to measure the effect of feedlot management practices on E. coli 0157:H7 prevalence. Management practices were identified that simultaneously impact cattle performance and E. coli 0157:H7 prevalence. These management practices represent the indirect relationship between E. coli 0157:H7 and feedlot profits. These specific management strategies should be interpreted with caution, as they were not robust through a sensitivity analysis. The general management strategy categories, however, were robust and consistent with previous research.

As concern about E. coli 0157:H7 increases, E. coli 0157:H7 management at the feedlot will become more important. The results from this thesis indicate that management decisions that impact E. coli 0157:H7 prevalence also impact feedlot profitability. By the same token, decisions that affect cattle performance also have implications for E. coli 0157:H7 management. A better understanding of the joint production process of cattle and E. coli 0157:H7, and the relationship of that process with profitability, will allow feedlot managers to employ optimal levels and methods of E. coli 0157:H7 control.

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