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Estimated Cost to a Commercial Feedlot of a Quarantine

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Potential introduction of contagious foreign animal diseases in the US has escalated in recent years with increased global commerce and travel and concerns about bioterrorism. In the event of a contagious animal disease outbreak, animal health department emergency management plans generally include animal movement restrictions and livestock operation quarantines. As emergency management plans are designed, understanding probable costs to industry participants of various disease management schemes is critical to developing economically efficient crisis management strategies. The purpose of this report is to demonstrate, with an example, probable costs associated with cattle quarantined in a commercial cattle feedlot in Southwestern Kansas.

Assumptions

To determine the economic impact of a quarantine in a cattle feedlot several assumptions were made. These assumptions include:

1. The feedlot has 40,000 head capacity
2. The feedlot turns inventory over approximately 2.5 times per year
3. Weekly fed cattle marketings under normal conditions are 1,900 head
4. Feed price is \$0.11 per pound dry matter
5. Finished fed cattle price is \$95.00 per cwt (live weight)
6. Cattle are placed on feed at 750 pounds
7. Cattle are fed for 129 days at the targeted harvest date
8. Finished market weight of cattle is targeted at 1,215 pounds
9. Long-run cattle feeding net return is \$20 per head (used for opportunity cost estimation)
10. The feedlot show list is current at the time the quarantine begins
11. Interest rate on capital and opportunity cost of cattle is 8% annually.

¹We gratefully acknowledge helpful suggestions and comments by Kevin Dhuyvetter.

Specifically ignored in these cost calculations are:

1. Additional costs associated with morbidity or mortality of cattle held beyond optimum
2. Loss in value of animals that have reduced yield grade and heavy-weight discounts from being fed too long (in the analysis presented here, the quarantine was not extended long enough for heavy-weight discounts etc. to become prevalent given cattle type and other assumptions, but if the quarantine persisted this would become a substantial loss component to the feedlot)
3. Added costs and lost customers that a feedlot would likely incur as a result of the event that caused the quarantine (e.g., dealing with adverse effects and direct costs if a contagious animal disease were present in the region).

As a result, cost estimates provided here are conservative lower-bound estimates.

Cost Calculation

The total estimated cost of a feedlot quarantine includes three major components. The first component is the additional net cost to feed cattle (cost of feed less added revenue from increased animal weight) that would have otherwise been sold. The second cost component is the opportunity cost of not selling the animals at the desired time. This opportunity cost includes the cost of delayed revenue from the sale of finished cattle. The last cost component is the revenue lost from holding the animals and thus not being able to place new cattle in the pens for future harvest, resulting in forgone future profit.

Additional Cost to Feed Cattle

The additional net cost to feed cattle each week is comprised of the additional feed cost less the added animal value associated with increased weight gain. The additional feed cost was estimated based on the amount of feed intake which is a function of the weight of the cattle. To compute the weight of cattle on feed, we multiplied average daily gain (ADG) by days on feed (DOF). ADG was figured using equations developed for the Cattle Risk Analyzer on the North American Institute for Beef Economic Research (NAIBER) web site (www.naiber.org). The formula used for estimating ADG is:

$$ADG \text{ (lbs/day)} = 2.5183 + 0.4849(\text{STEERS}) + 0.1946(\text{MIXED}) - 0.0543(\text{KS}) - 0.1409(\text{WINTER}) - 0.1972(\text{FALL}) - 0.0415(\text{SPRING}) + 0.0132(\text{DOF}) + 0.0079(\text{InWt}) - 0.0000007(\text{InWt})^2 - 0.00007(\text{DOF} \times \text{InWt}) + 0.00000006(\text{DOF} \times \text{InWt}^2)$$

where STEERS and MIXED are binary variables indicating if the pen contains only steers or both steers and heifers; KS indicates whether or not the cattle are located in Kansas; WINTER, FALL and SPRING indicate the time of year the cattle are placed

on feed; DOFeed is the days the cattle are on feed; and InWt is the weight of the cattle when they are placed on feed. We assumed cattle were placed on feed at 750 pounds (InWt=750), we assumed all cattle were steers (STEERS=1, MIXED=0), the cattle are in Kansas (KS=1), the season was assumed to be spring (WINTER=0, FALL=0, SPRING=1), days on feed (DOF) were calculated by starting with 129 days and adding 7 days for each week the cattle were held in quarantine.

ADG was multiplied by the total days on feed to estimate total gain and average animal weight for each week they were on feed. Animal weight was used to compute the feed each animal would be expected to consume. To figure feed consumption we used the dry matter intake formula from the *National Research Council's Nutrient Requirements of Beef Cattle* (1996). This formula is used in the Cornell Net Carbohydrate and Protein System and in Lusk (2007):

$$\text{Dry Matter Intake in lbs}_t = [(0.96(W_t/2.2))^{0.75}(0.2435\text{NE}_{\text{ma}}-0.0466 \text{NE}_{\text{ma}}^2-0.1128)/\text{NE}_{\text{ma}}] \times (\text{empty body fat adjustment factor}) \times 2.2$$

where NE_{ma} is the net energy value of the diet for maintenance (set at a constant value of 2.0 Mcal/kg), W_t is the weight in pounds at time t , and the empty body fat (EBF) adjustment factor has the following values: 1.0 for $\text{EBF} < 23.8$, 0.97 for $23.8 \leq \text{EBF} < 26.5$, 0.90 for $26.5 \leq \text{EBF} < 29.0$, 0.82 for $29.0 \leq \text{EBF} < 31.5$, and 0.73 for $\text{EBF} \geq 31$. EBF was estimated using the equation provided in Perry and Fox (1997) and Lusk (2007):

$$\text{EBF}_t = \frac{0.351(0.389(W_t/2.2) + 21.6(\text{yieldgrade}_t) - 80.8)}{0.389(W_t/2.2)} \times 100$$

where *yieldgrade* is set at a constant 2.5.

From dry matter intake we figured additional cost per week to feed the animal. We assumed a feed price per pound dry matter to be \$0.11. The dry matter intake formula above is daily dry matter intake. Therefore to figure additional cost per week we multiplied the estimated dry matter intake (DMI) by feed price and by 7 days/week:

$$\text{Added cost } (\$/\text{head}) = \text{DMI} \times \$0.11 \times 7.$$

Next we calculated additional animal value per week using cattle price and average weight. We multiplied the weight gained per week by the finished fed cattle price (assumed to be \$95/cwt):

$$\text{Added value } (\$/\text{head}) = (W_t - W_{t-1}) \times \text{Fed Cattle Price}/100$$

where W_t is the weight in pounds at time t , and t refers to the week of the quarantine.

The difference between the additional cost of feeding and the additional animal value would be one component of the quarantine cost:

$$\text{Additional net cost to feed animal (\$/head)} = [\text{DMI} \times \$0.11 \times 7] - [(W_t - W_{t-1}) \times \text{Fed Price}/100].$$

Opportunity Cost

Another cost component is the opportunity cost of not selling the animal at the optimal market time (129 days on feed in this scenario). The total opportunity cost had two factors in this example. The first portion of the cost was the interest cost of the revenue not received from the sale of the animal (interest cost for each week of delayed sale). If the animal would have been sold, the feedlot owner would have had access to the revenue the animal generated. However, the quarantine prevented the animal from being sold. For each week, this cost was the interest rate (8% annual rate) on the revenue that would have been received if the animal was sold at 129 days on feed. The second portion of the opportunity cost was an interest rate charge for the additional feed cost for the animal for each week of the quarantine. The opportunity cost is:

$$\begin{aligned} \text{Opportunity cost} = & [\text{Revenue at 129 days} \times 0.08 \times (\text{week of quarantine}/52)] \\ & + [\text{Added feed cost} \times 0.08 \times (\text{week of quarantine}/52)] \end{aligned}$$

Forgone Profit

The last cost component includes the profit lost on not being able to place future pens of cattle on feed because of the quarantine. If the quarantine had not been in effect, 1,900 head of cattle would have been sold each week. As the animals would have been sold, pens would have been filled with new cattle (that would be sold in 129 days). However, the quarantine does not allow the animals to be sold and the pens would not be available for new animals to occupy. Each week the quarantine is in effect, a portion of profit would be lost from not having available pens in which to place new animals.

Specifically, the feedlot is not receiving a portion of the \$20 per head profit assumed from the cattle in the new pens each week the quarantine continues. If the quarantine were to continue for 129 days, then the entire \$20 per head profit would be lost at that point in time. Each week the quarantine is in effect, 7/129 of the \$20 per head profit is lost. Since the \$20 profit would be received in 129 days, the portion of the profit lost was discounted to today's current dollars. The formula used to calculate this lost profit is:

$$\text{Foregone Profit} = [20 \times (7/129)]/[1.08^{(122/129)}]$$

The sum of the *additional net cost to feed animal*, the *opportunity cost*, and the *forgone profit* results in a *Total Cost per head for Each Week* of the quarantine for a given animal. Note for each additional week an animal is held in quarantine, the *Total Cost per head for Each Week* changes because animal weight and feed consumption changes.

Cumulative Cost Effect

After obtaining a cost per head for each week of the quarantine, the cumulative effect of each additional week was taken into account. For instance, week one of the quarantine would result in the above costs for one pen of cattle. In this example the feedlot markets 1,900 head of cattle per week. Week 1 would result in 1,900 head of cattle being held one week past the desired marketing time. So the total cost of the quarantine in week 1 would be the cost of holding 1,900 head for one additional week. Since each week 1,900 more head of cattle would be sold, the formula to calculate week 1 costs for any pen is as follows:

$$\text{Week 1 Total Cost} = 1,900 \times \text{Total Cost per head in Week 1}$$

In week 2 the feedlot would incur the cost of holding the previous week's 1,900 head for one more week in addition to the cost of another 1,900 head of cattle being held one week beyond desired marketing time. Week 2 total cost is:

$$\begin{aligned} \text{Week 2 Total Cost} = & 1,900 \times \text{Cost per head in Week 1} \\ & + 1,900 \times \text{Cost per head in Week 2} \end{aligned}$$

This pattern would continue throughout the quarantine period with an additional week of total cost being added each week of the quarantine and additional cattle that should have been sold being added to the group of cattle in the feedlot that are being held beyond the desired sale date.

Estimated Costs

The tables and graph below further illustrate the costs for these assumptions. Week 1 is the first week beyond the optimum sale date and week 2 is the second week beyond the optimum sale date, etc. Table 1 shows feeding performance and gain per week of the quarantine. As cattle are held on feed additional weeks, average daily gain declines because the cattle are reaching mature weight meaning cattle weight is increasing at a declining rate. Furthermore, as cattle are held in the feedlot longer than optimal, dry matter feed conversion increases because animal gain efficiency is declining.

Table 2 displays the estimated added feed cost and added animal value per week. As the quarantine continues, feed cost per head increases as the animals continue to eat more and added animal value per head decreases because rate of weight gain declines (the quarantine duration in this example is not long enough to result in overweight cattle that receive a discount). The additional opportunity cost and lost profit remain constant each week. While the cumulative effect of opportunity cost and lost profit is increasing, the costs are increasing at a constant rate. The weekly total cost per head is displayed in the final row of Table 2. The first week of the quarantine the net cost to the feedlot is about \$5.50/head, net cost increases to \$10/head by the 10th week of the quarantine. The estimated net costs shown are conservatively low estimates because if cattle were held more than a few weeks beyond optimum, they would likely start to become fleshy, have deteriorating yield grade, and thus would begin to lose substantial market value.

Table 3 illustrates the cost effect of new pens of cattle being ready to market each week. The total cost per week of the quarantine is displayed as well as the cumulative cost for each week. Figure 1 depicts the cumulative feedlot cost per week of the quarantine. The rapidly increasing nature of these costs is evident. During the first week the cost would be about \$10,000 and by the fifth week of the quarantine the cost is approaching \$200,000. The cost reaches \$1 million by week 11. Costs would continue to increase exponentially if the quarantine were to continue.

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Table 1: Feeding Performance and Gain for Each Week Cattle are in Quarantine after Optimum Sale Date												
	Weeks Cattle are Held In Quarantine beyond Optimal Marketing Date											
	1	2	3	4	5	6	7	8	9	10	11	12
Total Feeding Period Average Daily Gain (lbs/day)	3.53	3.45	3.38	3.30	3.22	3.15	3.07	2.99	2.92	2.84	2.76	2.69
Total Feeding Period Dry Matter Feed Conversion (lbs feed/lb gain)	5.81	5.90	5.98	6.07	6.16	6.26	6.35	6.44	6.54	6.64	6.73	6.83
Current Week Dry Matter Feed Intake (lbs/day)	21.49	21.67	21.84	21.99	22.13	22.25	22.36	22.45	22.53	22.60	22.65	22.69
Heaviest Cattle Weight (lbs)	1,230	1,244	1,256	1,268	1,278	1,288	1,296	1,304	1,310	1,315	1,319	1,322

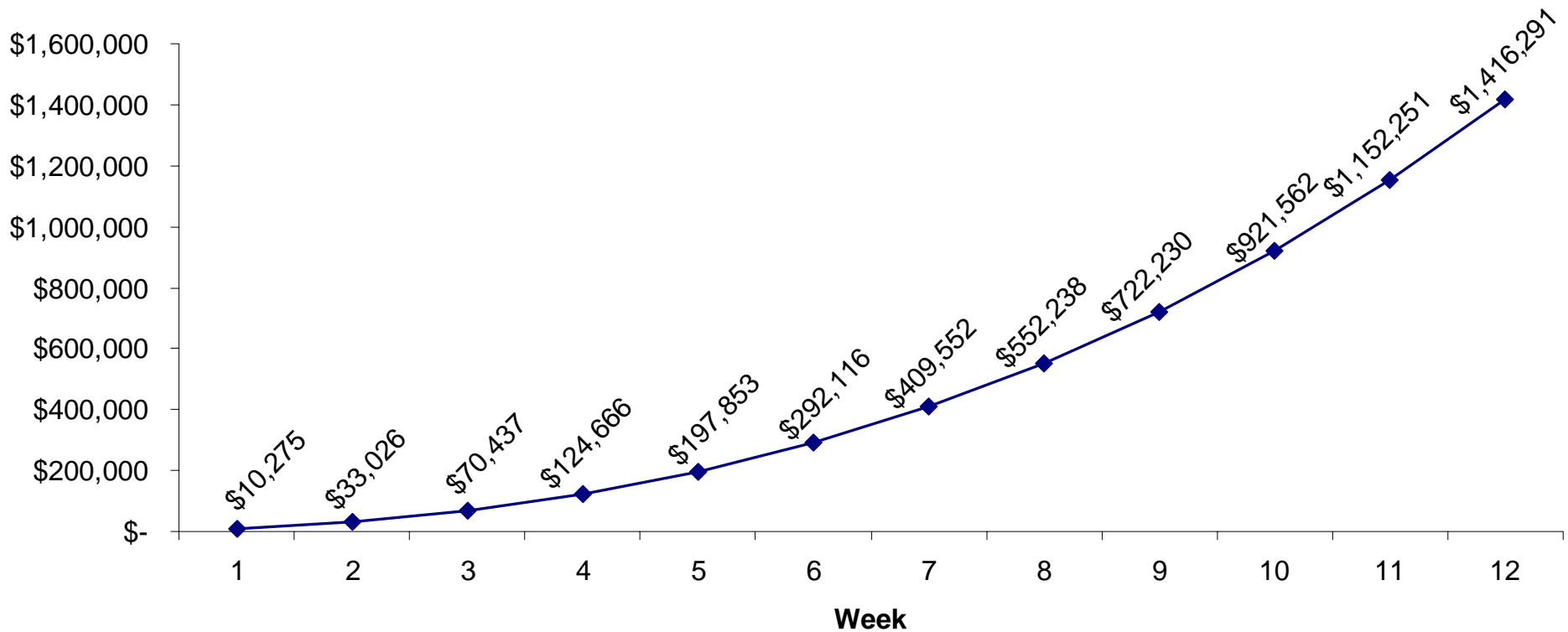
Table 2: Weekly Feed Cost and Added Value for Cattle in Quarantine after Optimum Sale Date

	Weeks Cattle are Held In Quarantine beyond Optimal Marketing Date											
	1	2	3	4	5	6	7	8	9	10	11	12
Weekly Feed Cost (\$/head)	\$ 16.67	\$ 16.81	\$ 16.94	\$ 17.05	\$ 17.16	\$ 17.26	\$ 17.34	\$ 17.41	\$ 17.48	\$ 17.53	\$ 17.57	\$ 17.60
Weekly Added Value (\$/head)	\$ 14.07	\$ 13.05	\$ 12.03	\$ 11.01	\$ 9.99	\$ 8.97	\$ 7.96	\$ 6.94	\$ 5.92	\$ 4.90	\$ 3.88	\$ 2.86
Opportunity Cost on Feed and Delayed Sales Revenue (\$/head)	\$ 1.80	\$ 1.80	\$ 1.80	\$ 1.80	\$ 1.80	\$ 1.80	\$ 1.80	\$ 1.80	\$ 1.80	\$ 1.80	\$ 1.80	\$ 1.80
Discounted Lost Profit of Delayed Placements (\$/head)	\$ 1.01	\$ 1.01	\$ 1.01	\$ 1.01	\$ 1.01	\$ 1.01	\$ 1.01	\$ 1.01	\$ 1.01	\$ 1.01	\$ 1.01	\$ 1.01
Net Cost (\$/head)	\$ 5.41	\$ 6.57	\$ 7.72	\$ 8.85	\$ 9.98	\$ 11.09	\$ 12.20	\$ 13.29	\$ 14.37	\$ 15.44	\$ 16.50	\$ 17.55

Table 3: Net Cost to 40,000 Head Feedlot of Quarantine by Week

First Week Group of Cattle would be on Show List ^c	Weeks Cattle are Held In Quarantine beyond Optimal Marketing Date											
	1	2	3	4	5	6	7	8	9	10	11	12
Week 1	\$ 10,275	\$ 12,477	\$ 14,659	\$ 16,819	\$ 18,958	\$ 21,076	\$ 23,173	\$ 25,250	\$ 27,306	\$ 29,341	\$ 31,356	\$ 33,351
Week 2		\$ 10,275	\$ 12,477	\$ 14,659	\$ 16,819	\$ 18,958	\$ 21,076	\$ 23,173	\$ 25,250	\$ 27,306	\$ 29,341	\$ 31,356
Week 3			\$ 10,275	\$ 12,477	\$ 14,659	\$ 16,819	\$ 18,958	\$ 21,076	\$ 23,173	\$ 25,250	\$ 27,306	\$ 29,341
Week 4				\$ 10,275	\$ 12,477	\$ 14,659	\$ 16,819	\$ 18,958	\$ 21,076	\$ 23,173	\$ 25,250	\$ 27,306
Week 5					\$ 10,275	\$ 12,477	\$ 14,659	\$ 16,819	\$ 18,958	\$ 21,076	\$ 23,173	\$ 25,250
Week 6						\$ 10,275	\$ 12,477	\$ 14,659	\$ 16,819	\$ 18,958	\$ 21,076	\$ 23,173
Week 7							\$ 10,275	\$ 12,477	\$ 14,659	\$ 16,819	\$ 18,958	\$ 21,076
Week 8								\$ 10,275	\$ 12,477	\$ 14,659	\$ 16,819	\$ 18,958
Week 9									\$ 10,275	\$ 12,477	\$ 14,659	\$ 16,819
Week 10										\$ 10,275	\$ 12,477	\$ 14,659
Week 11											\$ 10,275	\$ 12,477
Week 12												\$ 10,275
Total Cost for Week	\$ 10,275	\$ 22,752	\$ 37,410	\$ 54,229	\$ 73,187	\$ 94,263	\$ 117,436	\$ 142,686	\$ 169,992	\$ 199,333	\$ 230,689	\$ 264,039
Cumulative Cost	\$ 10,275	\$ 33,026	\$ 70,437	\$ 124,666	\$ 197,853	\$ 292,116	\$ 409,552	\$ 552,238	\$ 722,230	\$ 921,562	\$ 1,152,251	\$ 1,416,291

Net Cost to 40,000 Head Feedlot of Quarantine by Week



Assumptions:

- Feedlot has a 40,000 head capacity
- Feedlot has a 2.5 turnover inventory per year
- 1,900 head are marketed per week
- Feed price is \$0.11 per pound dry matter
- Cattle are placed on feed at 750 lbs
- Cattle are fed for 129 days
- Finished fed cattle price is \$95 per cwt live weight
- Finished market weight of cattle is targeted at 1,215 lbs
- Feedlot show list is completely current at the time the quarantine begins
- Interest rate on opportunity cost of cattle is 8%