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# **Feedlots, Air Quality, and Dust Control -Benefit Estimation**

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# Feedlots, Air Quality, and Dust Control-Benefit Estimation



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## Introduction

More than 17% of the total value of U.S. of cattle and calves comes from Texas while the total sales in U.S. were \$61.2 billion during 2007. The Texas Panhandle contributes the majority in Texas. For example, feedlots in Deaf Smith County in Texas earned \$965 million during 2007 in terms of cattle and calf sales, or 1.6% of the total value in U.S.

However, cattle also brings about the majority of atmospheric emissions from manure or animal activities. Sweeten (1996) revealed that approximately 900 kg of dry manure are left behind by an animal fed in a normal 150 day fattening period. The dry manure becomes air-borne dust particles and is emitted into the air by wind or animal activities. Dust from confined animal feeding operation (CAFO) is widely reported to adversely affect animal health, for example, Snowden et al. (1999) estimated an 8-kg difference between a healthy and a bovine respiratory disease infected calf over a 200-day feeding period, while Smith (1996) reported that a calf suffered from respiratory disease has 0.23kg less of average daily gain(ADG).

USDA has reported that 1.11 million head of cattle and calves in the U.S. died because of respiratory problem, resulting in \$692 million losses of total values in 2005. Texas lost 142,500 heads of cattle and calves which were around equivalent to \$88 million that same year. Therefore, there is no doubt that dust suppression is a pressing issue for both the government and the feedlot operators.

This paper attempts to shed light on how important and effective dust control is by employing a production and externality-based social welfare analysis concerned with dust in feedlots, and then compare the private and social benefits of dust control. A case study done near Amarillo where is located in the Texas Panhandle will also be used to develop empirical measures.

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## Theoretical model

### I Environmental Amenities

Assume that the dust emission level in feedlot  $i$  is depicted by a function of animal feeding operation size in terms of number of animals and denoted as  $e_i(Q_i)$ , where  $de_i/dQ_i > 0$ ; with the aim of capturing the externality effects, we assume that the dust concentration level in feedlot  $i$ ,  $e_i(Q_i, Q_{-i})$ , is a linear combination of the dust emission levels and can be expressed as (1) :

$$e_i(Q_i, Q_{-i}) = e_i(Q_i) + b_{ik}e_k(Q_k) \quad (1)$$

where  $b_{ik}$  is a transfer coefficient in terms of the distance between feedlot  $i$  and  $k$ ,  $\forall i \neq k$ . It is reasonable that  $b_{ik}$  is getting smaller while one feedlot is farther from the other.

Assume that the suppression effect of abatement technology is the same among all feedlots, and  $e_k(Q_k, S) < e_k(Q_k)$  under valid dust suppression technology. The total dust concentration level at feedlot  $i$  under dust control at all feedlots,  $e_i(Q_i, Q_{-i}, S)$ , is :

$$e_i(Q_i, Q_{-i}, S) = e_i(Q_i, S) + b_{ik}e_k(Q_k, S) \quad (2)$$

where  $S$  denotes the total suppression effects of the abatement technology at all feedlots.

### II AFO profit maximization problem

Assume AFOs face mortality rate  $u$  % and morbidity rate  $v$  %, and both rates are affected by dust concentration level. Besides, health cattle weight  $w_1$  and cattle suffer from respiratory problem weight  $w_0$ .  $P$  is the unchanged per pound price of cattle,  $Q_i^c$  represents the capacity of each feedlot, and  $c_i'(w)$  and  $F_i$  are referred to as the marginal costs and fixed costs, respectively. The maximization problems ex ante and ex post dust control are addressed as follows, respectively:

(1) No dust suppression:

$$\begin{aligned} \text{Max} \pi_{0,i}^1 &= (1 - v(e_i(Q_i, Q_{-i}))) \cdot \{[P - c_{i1}'(w_1)] \cdot [1 - u(e_i(Q_i, Q_{-i}))]\} \cdot w_1 \cdot Q_i \\ &\quad + v(e_i(Q_i, Q_{-i})) \cdot \{[P - c_{i0}'(w_0)] \cdot [1 - u(e_i(Q_i, Q_{-i}))]\} \cdot w_0 \cdot Q_i - F_i \\ \text{s.t. } Q_i &\leq Q_i^c \end{aligned} \quad (3)$$

(2) With dust suppression in all feedlots :

$$\begin{aligned} \text{Max} \pi_{0,i}^2 &= (1 - v(e_i(Q_i, Q_{-i}, S))) \cdot \{[P - c_{i1}'(w_1)] \cdot [1 - u(e_i(Q_i, Q_{-i}, S))]\} \cdot w_1 \cdot Q_i \\ &\quad + v(e_i(Q_i, Q_{-i}, S)) \cdot \{[P - c_{i0}'(w_0)] \cdot [1 - u(e_i(Q_i, Q_{-i}, S))]\} \cdot w_0 \cdot Q_i - m_i'(Q_i) - F_i \\ \text{s.t. } Q_i &\leq Q_i^c \end{aligned} \quad (4)$$

## Data Description

- 73 feedlots in Texas were analyzed, and number of feedlots of capacity>32000, 16000<<31999, and <15999 were 35, 24, and 14, respectively;
- Cattle in each capacity were further classified according to their weight and estimated by the proportion of placements to the annual inventories and marketing based on the USDA reports;
- Some numerical values are referred to the follows: monthly morbidity rates of respiratory disease were estimated by Sanderson et.al.(2008); incidence of mortality rate is around 1/10 of morbidity rate; ADG loss per cattle which is sick but treated is 0.132 lb per day and the cost of per ADG loss is \$0.85; average treatment cost of each disorder cattle is estimated as \$12.59 by USDA(2009);
- Dust concentration level is in terms of dry matter obtained from manure: 6% of weight x 11% (dry matter proportion) x 1.11 (moisture content), and transformed as an adjustment coefficient (a) of morbidity rate in each individual feedlot by the following function :

$$a = 1 \pm 0.2 * (1 - e^{-\frac{(x-m)}{2m}}),$$

where  $x$  is the dust level in each feedlot, and  $m$  is the average dust level among all feedlot.

## Preliminary Results

Table 1 Morbidity rate of cattle and the cost of dust control by solid-set sprinkler by month and weight category				
Cattle weight	Morbidity Rate			Total Cost of Dust Control \$/Hd Capacity
	1 <sup>st</sup> month after arriving	2 <sup>nd</sup> month after arriving	3 <sup>rd</sup> to 6 <sup>th</sup> month after arriving	
< 550lb	13.4%	7.5%	1.0%	\$4.09
550lb << 700lb	8.4%	3.4%	1.9%	\$2.96
> 700lb	2.3%	0.9%	0.35%	\$2.79

Table 2 Estimated Annual Loss by Weight and Capacity Category (in dollars)							
	Capacity of feedlot	Loss by cattle weight				Total loss w/o cost of dust control	Total loss with cost of dust control
		< 599lb	600lb << 699lb	700lb << 799lb	>800lb		
No dust suppression	<15999	\$ 49,179	\$ 42,043	\$ 25,690	\$ 8,950	\$125,863	
	16000<<31999	\$107,032	\$ 83,641	\$ 54,717	\$ 20,602	\$264,452	
	>32000	\$239,741	\$205,714	\$125,753	\$ 43,782	\$614,990	
With dust suppression in all feedlot*	<15999	\$ 44,261	\$ 37,839	\$ 23,121	\$ 8,054	\$113,276	\$150,182
	10% 16000<<31999	\$ 96,328	\$ 75,277	\$ 48,759	\$ 18,542	\$238,907	\$308,527
	>32000	\$215,767	\$185,143	\$113,178	\$ 39,403	\$553,491	\$697,574
	<15999	\$ 34,426	\$ 29,430	\$17,983	\$ 6,265	\$ 88,103	\$125,009
	30% 16000<<31999	\$ 74,922	\$ 58,549	\$37,924	\$14,421	\$185,816	\$255,436
	>32000	\$167,819	\$144,000	\$88,027	\$30,647	\$430,493	\$574,576

\* The dust suppression efficiency is assumed to decrease 10% and 30% of morbidity and mortality rate.

## Discussions

- Dust suppression decreases the mortality and morbidity rate, and further reduce the AFO's loss;
- AFOs with higher capacity have economies of scale on dust suppression costs and hence have higher loss reduction rate;
- Weather conditions such as wind direction, temperature, and humidity will be considered in the adjustment coefficient of dust concentration level in the extended research;
- Dust suppression efficiency needs to be uncovered to estimate the mortality and morbidity rate;
- Social welfare analysis will be employed, that is, a neighborhood utility maximization problem will also be used to determine the optimal dust control strategy for a private and social standpoint, and the design of incentive mechanism will be examined.

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