Manure BMP Adoption among North Dakota Animal Feed Operations

by

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ABSTRACT: Regulations governing animal waste storage are primarily a state-level issue. Protecting water resources from animal waste contamination will depend upon how effective state-level animal waste regulations are in encouraging livestock producers to handle waste appropriately. Survey results from North Dakota indicate beef cattle feeding operations do not always comply with state regulations requiring adoption of manure storage BMP's. This is most likely due to incomplete inspection schedules by the regulatory agency. Statistical results suggest herd size plays a much larger role than regulation in promoting adoption of manure storage BMP's.

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Introduction

Nutrient surpluses from manure associated with livestock production poses a significant threat to water quality across the United States (EPA, 1992; Letson and Gollehon, 1996; Gollehon and Caswell, 2000). As a result, promoting proper processing and handling of manure is an important public policy goal. The Environmental Protection Agency (EPA), under authority granted by the Clean Water Act (CWA), is the lead agency for regulating animal waste at the Federal level. Current EPA regulations apply to the waste handling methods of Concentrated Animal Feeding Operations with 1000 or more Animal Units (AU's). Specifically, CAFO's of over 1000 AU are considered point sources of pollution and are required to receive a permit under the National Point Discharge Elimination System (NPDES). The EPA is proposing to lower the CAFO size limit to cover CAFO's with 500 AU's. The proposed change should encourage smaller CAFO's to adopt manure handling methods which limit discharges of manure into surface and ground water.(EPA, 2001)

Currently, smaller CAFO's are subject primarily to state-level manure regulations rather than EPA regulations. As noted by Metcalfe (2000), most current Federal manure management legislation defers regulatory responsibility to individual states when state-level regulations have either lower AU thresholds or are viewed as being more stringent than EPA standards. Currently, 43 states are identified by the EPA as having manure management standards that are at least as stringent as EPA requirements (EPA, 1999). For these states, the effectiveness of state manure management regulations will determine whether or not animal waste poses a threat to water quality.

Given the importance of state-level regulations, research examining the manure

management practices of CAFO's should address how state-level manure regulations influence the manure management practices of CAFO's. In particular, determining if CAFO's actually comply with the requirements of state-level manure regulations is of critical importance. The present research focuses on this issue by analyzing the effectiveness of state-level manure management regulations in North Dakota.

North Dakota identified manure as a potential threat to water quality in 1972, and has required all CAFO's with more than 200 animal units, regardless of type, to receive approval to operate from the State Health Department since that time (North Dakota Livestock Regulations, 1989). To receive "approval to operate", North Dakota requires that manure from CAFO's be kept in facilities capable of handling a minimum of six months of manure production and/or a 3.5 - 4.2 inch rainfall in a 24-hour period.

These standards for manure storage represent North Dakota's manure Best Management Practices (BMP's). Requiring on-farm manure storage facilities to meet these standards are intended to reduce the likelihood of water contamination by a CAFO. It is important to note that the BMP's do not require adoption of specific facilities, only that the facilities used meet the chosen standards. Since the BMP's require only meeting a standard rather than adoption of a specific facility type, the CAFO is free to employ whatever storage method is most appropriate for the location of the CAFO. The latter issue is critical. Location-specific attributes, such as proximity to water and crop acreage, mean that not all CAFO's will be free to adopt all types of manure storage facilities and some CAFO's will be physically unable to comply with the regulation.

As mentioned previously, North Dakota state law requires all CAFO's over 200 AU to

receive "approval to operate" from the State Health Department. Compliance with this regulation is enforced through fines, and failure to comply with the BMP standards can lead to a $10,000.00/day fine for each day that a CAFO is out of compliance with the regulation (North Dakota, 1999). In practice, enforcement of this regulation does not extend to all CAFO's. Current Health Department policy is to inspect CAFO's of 1000 AU annually and to inspect CAFO's of less than 1000 AU on an "as needed" basis when complaints are received (Halberstroh, 2001). This leads to an inspection gap between the *de jure* requirements of the regulation and the *de facto* enforcement of the policy.

Assuming that adopting the state-mandated BMP's is less profitable than operating without adoption, the inspection gap creates an incentive for CAFO's below 1000 AU either not to receive "approval to operate" and adopt the required BMP's or to fall out of compliance with the BMP standard once "approval to operate" has been obtained. If BMP adoption is profit-reducing, CAFO's will adopt the mandated BMP's only as they perceive the likelihood of enforcement increasing. CAFO behavior in North Dakota bears out this observation. Surveys of beef CAFO's in North Dakota indicate that only 58% of operations with "approval to operate" actually adopted the required manure BMP's (Klenow and Birchall, 2000). The low adoption rate among permitted operations in North Dakota raises serious questions about the overall effectiveness of state-level manure management regulations.

To assess the effectiveness of state-level manure management regulations, the present research examines whether or not state-level manure management regulations influence manure BMP adoption rates among beef CAFO's in North Dakota. A manure BMP adoption model conditioned on CAFO size (as measured by herd size and acreage), regional nutrient demand (as

measured by regional crop production) and state-level manure management regulatory status is developed and applied to farm-level survey data describing beef cattle CAFO's in North Dakota. Results indicate that both regional crop coverage and state-level regulations influence the manure handling practices of CAFO's, but these impacts tend to be relatively small in comparison to the effects of CAFO herd size.

Previous Research

Manure, and how to deal with it, has seen a significant quantity of economic research. Much of this research addresses how alternative manure management policies influence on-farm income. This category of research is typified by Ashraf and Christenson (1974); Foster (1975); Fleming, Babcock and Wang (1998); Van Dyke et al.(1999); and Van Dyke, Bosch and Pease (1999). While early work in this area found that manure management polices imposed significant costs on producers, more recent work which recognizes the nutrient value in manure has either shown smaller costs or actual benefits to producers who utilize manure as a source of nutrients (see Van Dyke et al. or Fleming, Babcock, and Wang).

Manure management practices are a reflection of the production technology employed by the CAFO. Changes in manure management, such as adoption of BMP's, represent a fundamental change in production technology by the CAFO. The question then is whether or not environmental regulations promote changes in production technology that lead to reductions in manure pollution. However, the ability of an CAFO to adopt alternative manure management practices will be limited by the unique attributes of the CAFO. Simply put, not all CAFO's can adopt manure BMP's. This problem stems from asset heterogeneity (Bellon and Taylor, 1993;

Perrin and Winkelmann, 1976). Asset heterogeneity, the differences in the physical characteristics of an enterprise, limits the ability of some CAFO's to adopt manure BMP's (Safley, 1994).

Asset heterogeneity has been touched on in previous animal waste research, but has never been a primary focus. Van Dyke et al. (1999) showed that on-farm variations in soil quality could lead to nutrient leaching from manure applications and suggested that manure only be applied to soils which had higher capacities for absorbing nutrients. This observation captured the effects of asset heterogeneity, but did not address how asset heterogeneity influences the decision to adopt alternative manure management programs. Similarly, the recent theoretical work by Innes (2000) and Goetz and Zilberman (2000) showed how optimal policies needed to vary spatially in order to reflect the relative differences in pollution threat posed by different livestock enterprises. However, these studies did not address how heterogeneity influences the choice of manure management methods at the farm level. Both assume adoption of required manure management practices, when in fact the unique characteristics of individual CAFO's may mitigate against adoption. Indeed, with the notable exception of Schnitkey and Miranda (1993), most studies assume that CAFO's adopt the manure management practices required by policy when in fact they may not. As a result, while asset heterogeneity is obviously recognized in current research, its influence in determining whether or not CAFO's will actually adopt the recommended techniques or react to the proposed policies is not addressed. This research addresses this issue by accounting for variations in size and location that may influence the ability of a CAFO to adopt manure BMP's required by state-level regulations.

This research also recognizes that multiple factors affect the decision to adopt a particular

set of manure management practices. For adoption to occur, manure management techniques must either be the most profitable or least cost method of dealing with animal waste for a particular CAFO (Fleming, Babcock, and Wang, 1998; Carreira and Stoecker, 2000). Both profitability and cost will in turn be conditioned upon the heterogeneous attributes of the animal feed operation adopting the manure management practices. Since not all CAFO's will be equally able to adopt manure BMP's, the effectiveness of environmental policies promoting adoption of manure BMP's will be limited by farm attributes. Establishing how environmental regulations interact with the heterogeneous attributes of CAFO's in choosing manure management techniques is critically important for all regions faced with surpluses of manure.

Empirical Model

Compliance with North Dakota's manure BMP adoption regulation is mixed. Table 1 summarizes the responses to a recent survey by Klenow and Birchall (2000) of 108 North Dakota beef CAFO's. As the responses indicate, only 37% of producers sampled who should have had "approval to operate" actually operated with approval from the North Dakota State Health Department. Additionally, out of all operations with "approval to operate", only 58% of those surveyed had adopted the manure BMP's required by the permitting process. The manure BMP adoption rate among CAFO's without "approval to operate" was 10.8%. These results suggest that the State Health Department's current monitoring and enforcement practices create an incentive for CAFO's not to adopt the mandated BMP's. Additionally, given the low rate of BMP adoption among CAFO's with "approval to operate" from the State Health Department, the influence and effectiveness of North Dakota's manure regulations on adoption rates of

manure BMP's are unclear.

The methods a CAFO uses to handle manure are a reflection of the production technology used by the CAFO to produce livestock. Therefore, the choice between alternative levels of BMP adoption is a choice between alternative production methods. An individual CAFO will choose among alternative sets of manure management practices and opt for the set which is most profitable for that CAFO.

Profitability under a given set of manure management practices will depend upon the physical attributes of a CAFO (such as proximity to water, crops grown, and production facilities), the number of livestock raised, and the regulatory status of the CAFO (in the present case, does the CAFO have "approval to operate"). Physical traits, herd size and regulatory status of the CAFO are contained in the vector . For the purpose of examining BMP adoption in North Dakota, profits when the CAFO adopts the set of required BMP's are denoted $^{B}(\ )$ while the profits when the required BMP's are not adopted are denoted $^{NB}(\ )$. Assuming that not adopting is more profitable than adopting the mandated BMP's implies that:

1) $^{B}(\ ) < {}^{NB}(\ )$

To promote adoption, the State Health Department imposes a fine, *f,* where *f* is set such that:

$^{B}(\ ) \quad {}^{NB}(\ ) - f$

and any profit advantages to be had by non-adoption are lost to the fine.

Equation 2) assumes that the fine *f* is imposed with absolute certainty. As the survey results in Table 1 suggest, this may not be the case. There is actually a probability that non-compliance will not be detected and the fine may not be imposed. Denoting the probability that the fine is imposed as then the decision to adopt can be expressed as:

3) $\pi^{B} \begin{cases} > \pi^{NB} - \phi f \\ = \pi^{NB} - \phi f \\ < \pi^{NB} - \phi f \end{cases}$

In the situation described by equation 3), the fine will promote adoption only if the probability of the fine being imposed is sufficiently high as to cause $^{B}(\ )$ $^{NB}(\ ) - f$. If that is not the case, then the fine will not promote BMP adoption.

Equation 3) reduces the BMP adoption decision to a comparison of profits between adopting and not adopting, the fine for not adopting, and the probability of the fine being imposed. The difference in profits will depend upon the physical traits of the CAFO, which is the issue of asset heterogeneity, while the probability of the fine being imposed will depend upon enforcement by the State Health Department.

It is impossible to identify *a priori* how a CAFO's attributes interact with the probability of enforcement. For example, while it is reasonable to assume that having regulatory approval from the state should promote adoption of less-polluting production methods, variations in CAFO attributes do not make this a foregone conclusion. Compliance with the BMP regulation can, however, be identified empirically. Rearranging equation 3) shows that a CAFO will adopt the mandated CAFO's if:

4) $\frac{\pi^{NB} - \pi^{B}}{f} \geq \phi$

or if the difference in profits between not-adopting and adopting weighted by the fine is at least as great as the probability of enforcement. This reduces the weighted difference in profits to a

probability expression. If profits under both decisions are random variables and follow a Weibull distribution, then the weighted difference in profits which defines the BMP adoption decision can be described as a random variable distributed logistically (Domencich and McFadden, 1975). Direct estimation of profits is unnecessary as equation 4) can be expressed as a simple logit model. The decision to adopt or not adopt BMP's is then modeled as a binomial logit model where the explanatory variables are the elements of the attribute vector, . Inclusion of the asset vector captures the effects of asset heterogeneity.

Results

Using data from the Klenow and Birchall survey of BMP adoption among North Dakota Beef CAFO's, the type of manure storage facilities used by North Dakota beef producers was modeled as a binomial logit using the econometric package *LIMDEP*. Beef CAFO's were classified as either having or not having adopted manure BMP's (following the previously given definition used by the North Dakota State Health Department). The explanatory variables consisted of 9 continuous variables and 3 discrete variables. The continuous variables were the number of cattle on the CAFO (in AU), the acres available for manure spreading on the CAFO, distance from the CAFO to a surface water source (in feet); and county level acreage for corn, oats, soy, dry beans, canola, and hay in the CAFO's county. Acreage available for manure spreading, soil testing frequency, and distance to surface water are all intended to capture the heterogeneous physical and management traits that influence the manure BMP adoption decision. The regional crop acreage data supplements the survey data and comes from North Dakota National Agricultural Statistics Service (NASS). It serves as a measure of regional nutrient demand by

crops in close proximity to the CAFO.[1]

The discrete variables were: winter lot, for beef CAFO's that serve only as a winter feeding site[2]; P testing, for those facilities that use a Phosphorus rather than Nitrogen-based manure management plan; and the CAFO's regulatory approval status. The CAFO's regulatory status was given as a 0 if the CAFO lacked approval to operate from the State Health Department. The regression coefficients for the logit model are contained in Table 2.

The logit model performed very well in describing the BMP adoption decision by North Dakota beef CAFO's. Unlike conventional least squares regressions, limited dependent variable models lack a single reliable goodness of fit measure (Maddala, 1987). However, both the Likelihood Ratio Test (57.3 with 12 degrees of freedom) and the McFadden's R^2 (0.526) indicated a relatively good fit for the model. Additionally, the model successfully predicted 86.8% of the adoption decisions, as is shown in Table 3.

Among the coefficients for the explanatory variables, acreage measures are generally only marginally significant. On-farm acreage is significant only at the 0.2 level and has a negative sign. This is somewhat unexpected, but manure storage may be less critical on CAFO's with larger geographic footprints. Among the regional crop coverage measures only oats and hay are significant below the 0.2 level. Since these crops are primarily used for animal feed, their significance in predicting manure BMP compliance may have less to do with nutrient demand

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[1]Prices are excluded from the data set. Since the data set is cross-sectional and covers only North Dakota, there is inadequate spatial variation in prices and including prices would make the data set collinear. Physical measures are therefore substituted.

[2]Winter feeding operations are currently exempt from most state-level environmental regulations in North Dakota.

than with co-location of animal feed supply. In general, these results appear to suggest that demand for manure as a nutrient source, measured as both on- and off-farm acreage, does not play a significant role in determining how a CAFO handles its manure.

Proximity to water also does not appear to play a significant role in manure BMP adoption. The parameter measuring distance to surface water is insignificant, suggesting that proximity to water does not make North Dakota CAFO's more or less likely to adopt manure BMP's. From a policy standpoint, this outcome should raise water quality concerns. Another insignificant parameter which is of concern is the dummy variable representing those beef CAFO's which only house cattle during the winter. North Dakota currently exempts winter feeding operations from most environmental regulations, so the lack of a significant difference between these operations and other types of beef CAFO's suggests that there is no difference between regulation exempt and non-exempt CAFO's.

Herd size and regulatory status, both key parameters, are significant. Herd size and regulatory status (having "approval to operate") are significant at the 0.01 level. The contribution these two factors make to manure BMP adoption rates is shown in Figure 1. In general, receiving "approval to operate" from the North Dakota Health Department does increase the likelihood of adopting manure BMP's, but this improvement is more pronounced at relatively larger herd sizes. At the permitting threshold of 200 AU, receiving "approval to operate" translates to a 21% increase in the likelihood of adopting manure BMP's when compared to a CAFO without "approval to operate". At larger herd sizes, obtaining "approval to operate" leads to relatively greater increases in the likelihood of adopting manure BMP's, as can be seen in Figure 1. North Dakota's permitting process appears to be most effective for relatively large

herd sizes.

Conclusions

Current EPA regulations require permitting of CAFO's of 1000 AU or more. Proposed regulatory changes would reduces this threshold to 500 AU and would apply EPA rules to CAFO's currently covered only by state-level manure management regulations. Evidence from North Dakota, where state regulations require BMP adoption by all CAFO's of 200 AU or larger but where inspection only routinely applies to CAFO's of 1000 AU or larger, suggests that state-level manure regulations promote adoption of manure BMP's but their effectiveness is limited.

As an example, at the permitting threshold of 200 AU having "approval to operate" increases the likelihood of adopting state-defined manure BMP's by about 21%, while for the average beef herd of 372 AU having "approval to operate" increases the probability of adoption by approximately 40%. In comparison, for a CAFO without "approval to operate" rising from 200 to 372 AU increases the probability of adopting manure BMP's by only 0.2%. Larger herd sizes combined with "approval to operate" seem to promote higher rates of BMP adoption. Given that current State Health Department practices call for annual inspections only of relatively larger CAFO's, this result is not surprising. The gap in inspection by the State Health Department appears to limit the success of the "approval to operate" process. Lack of uniform inspections by the State Health Department creates an incentive for CAFO's not to comply with BMP adoption regulations until the CAFO becomes sufficiently large as to warrant inspection.

At a larger level, the mixed influence North Dakota's manure BMP regulations exert over the operations of beef CAFO's suggest the regulatory changes proposed by the EPA may be an appropriate extension of existing policies if the extension increases the perceived likelihood of

enforcement. However, the results from North Dakota may only be an exceptional case and research addressing the impacts of state-level manure management regulations in other regions of the United States is needed.

The relative unimportance to the manure BMP adoption decision of factors such as regional cropping patterns, on-farm acreage, and proximity to water is another point of concern raised by this research. These parameters do not appear to significantly affect the decision by North Dakota CAFO's to adopt manure BMP's. Regional crop coverage was generally insignificant in explaining manure BMP adoption decisions, while higher on-farm acreage levels actually reduced the likelihood of adopting manure BMP's. This suggests that regional nutrient demand for manure does not influence on-farm manure handling procedures while CAFO's with greater on-farm acreage may be less concerned with manure storage than more compact CAFO's. The end conclusion is that herd size appears to be the dominant factor in influencing on-farm manure storage decisions.

Table 1: Regulatory Status and BMP Adoption among North Dakota Beef CAFO's

BMP Adopt:		Approval to Operate: *Yes*		*No*		
		< 200 AU	*>200 AU*	*< 200 AU*	*>200 AU*	*Total:*
Yes	*< 200 AU*	8		3		11
	>200 AU		17		4	21
No	*< 200 AU*	12		40		52
	>200 AU		6		18	24
Total:		20	23	43	22	108

Table 2: Logit Coefficients for Manure BMP Adoption by Beef CAFO's in North Dakota

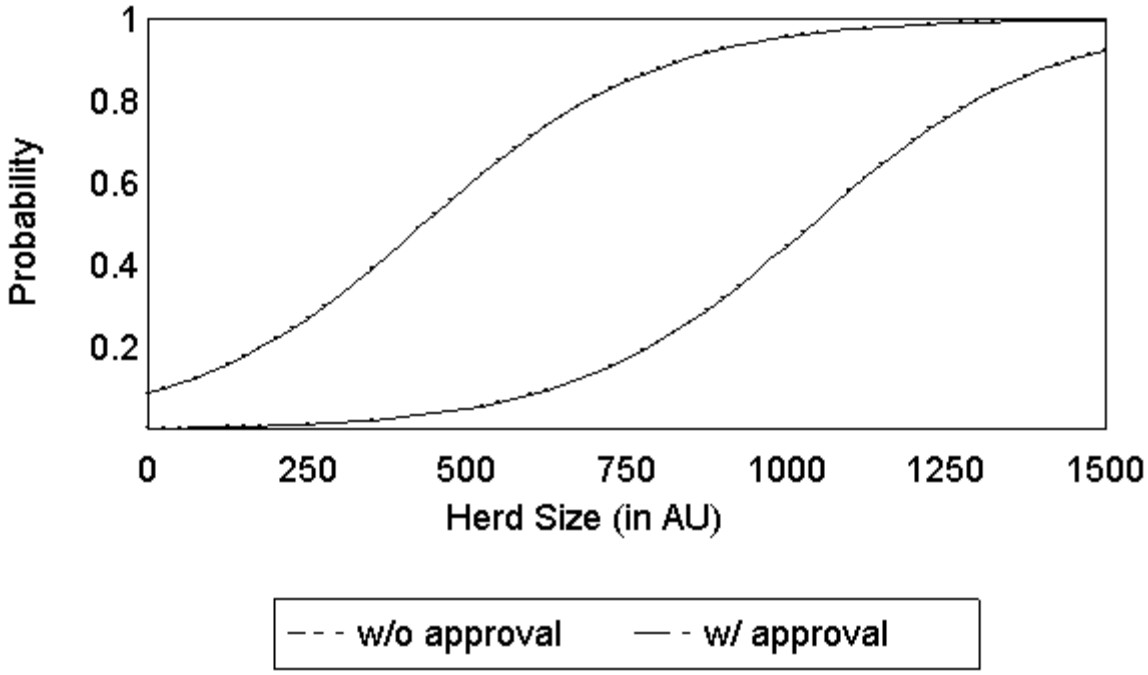
Parameter (Units)		Coefficient (t-value)	t value d. of f. = 79
Constant		-5.01982	-3.18264
Herd Size (AU)		0.00541919	2.85756
Winter Lot (0/1)		0.925041	0.974451
On-Farm Acreage (acres)		-0.000461787	-1.28489
P Rule (0/1)		2.24646	1.61706
Water Distance (feet)		1.62317E-05	0.0908347
Approval (0/1)		3.29411	3.3545
Corn (acres)		3.56088E-05	1.05265
Oats (acres)		0.000253075	1.981
Soy (acres)		-1.75973E-05	-1.46964
Dry Beans (acres)		4.65938E-05	1.10442
Canola (acres)		3.31951E-05	0.991943
Hay (acres)		-7.23976E-05	-1.85656
Log Likelihood Test	2 =	57.3	
	d. of f. =	12	
McFadden's R^2 =		0.53	

Note: Missing responses to some questions reduced the sample for the logit model to 91.

Table 3: Prediction Results of Manure BMP Adoption Model

	Predicted:		
Actual:	*No BMP*	*Yes BMP*	*Total*
No BMP	60	5	65
Yes BMP	7	19	26
Total	67	24	91

Figure 1: Adoption of Manure BMP's by North Dakota Beef CAFO's across Herd Size and by Approval Status



NOTE: Evaluated at means of continuous variables, and at mode of categorical variables.

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