Journal of Agricultural and Applied Economics, 28,1(July 1996):193–202

Manure Value and Liveweight Swine Decisions

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ABSTRACT

Produced as a joint product, economic theory suggests that manure value could influence livestock management decisions such as herd size and optimal market weights. This study examines the concept of manure value and its connection with optimal replacement age or market weight. A model of a swine finishing operation representative of North Carolina conditions is developed. Over the range of conditions considered, manure value is negative and does not affect market weights. The marginal per head change in manure value is small relative to the marginal per head change in net returns from pork production. Further, economies of scale with respect to irrigation cause manure value to increase with herd size.

Key Words: manure value, market weight, response surface, swine.

The swine industry is undergoing a dramatic shift toward fewer and more highly concentrated farms. This trend has been particularly strong in North Carolina, where only 10% of the hog farms produce 80% of the state's market hogs. Over 40% of the North Carolina hog farms manage herds in excess of 5,000 head (U.S. Department of Commerce).

Manure, produced as a joint product with liveweight, becomes increasingly important as farm animal numbers increase. Livestock manure has been viewed as an organic source of crop nutrients, and therefore an important feature in sustainable farming systems (Magdoff). However, mismanagement of manure stocks can lead to environmental problems and increased scrutiny from public officials who oversee environmental protection. As manure volume increases, the farm manager must devote greater resources toward manure handling activities to ensure that manure nutrients are utilized efficiently and in accordance with environmental standards.

Economic theory suggests that liveweight production decisions are dependent on manure handling decisions. The optimal market weight for a hog is where the combined value of pork and manure in the last pound of liveweight is exactly offset by the marginal cost to produce that last pound of liveweight and dispose of the incremental increase in manure volume. Typically, however, swine and poultry studies which analyze livestock herd decisions consider only the meat value of an animal (e.g., Chavas, Kliebenstein, and Crenshaw; Brown and Johnson; Govindasamy, Liu, and Kliebenstein).

The objective of this research is to incorporate manure value into livestock production decisions. Herd size, market weight, ration composition, and genetic stock are some of the important decisions that a manager of a livestock operation must consider. This study focuses only on the sensitivity

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This research was completed while Dr. Roka was a research associate at North Carolina State University. The work was partially funded by a grant from the North Carolina Pork Producers and Agricultural Foundation.

The authors wish to thank Drs. Jim Barker and Kelly Zering of North Carolina State University and two anonymous reviewers for their help and guidance on earlier work. Florida Agricultural Experiment Station Journal Series No. R-04937.

of herd size and market weight decisions from changes in manure value. Ration and genetic decisions are beyond the scope of this analysis.

This research makes two primary contributions. First, a framework is developed to simultaneously consider both manure production (herd size and market weight) and manure disposal (treatment and cropping) decisions. In previous studies, manure value has not been included in livestock production decisions. Second, this work uses a systems approach which allows us to measure the sensitivity of manure value on liveweight production decisions. Combined, these contributions provide some new insights about animal manure management.

The analysis proceeds with a discussion about manure value and a description of a conceptual model that incorporates it into herd management decisions. A response surface of manure value is estimated and results are nested in a decision model of animal replacement. Sensitivity analysis is completed for manure value and its impact on herd management.

Manure Value

Manure value, V_m, is defined within the context of crop production, where manure applications supply crop nutrients. New avenues of manure utilization are under investigation, and in the future, manure may prove to be an economical source of energy and/or a livestock feed supplement. At such time, the above definition of manure value could be expanded.

A common way to value manure has been to sum the commercial value of its component nutrients (Badger; Honeyman). For example, if 1,000 gallons of liquid manure contain 25, 20, and 15 pounds of nitrogen, phosphate, and potash, respectively, and the corresponding commercial fertilizer prices are $.20, $.25, and $.15 per pound, then the monetary summation equals $12.25. Nutrient value, however, is an incomplete measure of manure value. At best, it is a measure of replaced commercial fertilizer. Manure delivers nutrients in fixed proportions, and only those nutrients which positively contribute to crop yield are part of manure value. Applying manure to satisfy crop nitrogen needs usually implies that phosphorus and potassium are supplied in excess amounts. The value credit given to excess nutrients is zero. More importantly, a measure of replaced commercial fertilizer considers only the *benefits*[1] of manure applications. A value for manure is dependent also on the *costs* of delivering manure nutrients to a crop enterprise and the opportunity costs of selecting crops for their nutrient uptake ability rather than for their income generating ability.

Manure value depends on the combination of three decisions which form the basis of any manure management plan: level of biological treatment, total area receiving effluent, and the specific crops to which manure will be applied. A producer chooses a treatment level, acreage, and crop (nutrient demand) subject to two constraints. First, all manure nutrients produced by the swine house must be "treated" or utilized in crop growth. Second, crop nutrient application rates must comply with predetermined environmental limits.

In this study, treatment refers to activities which reduce nutrient concentration of fresh manure. Nitrogen is the primary nutrient of environmental concern in North Carolina, and treatment activities involve the volatilization of nitrogen into the atmosphere through the use of anaerobic or aerobic bacteria. Treatment level is a function of specific technology. Slurry pits and lagoons are two technologies examined here. Manure collected in a slurry pit (5% solids) loses up to 25% of the original nitrogen excreted (Midwest Plan Service-18). Alternatively, anaerobic lagoons (less than 1% solids) volatilize over 90% of the original nitrogen (Barker 1990). North Carolina data further show that nitrogen volatilization varies directly with lagoon size (Safley).

Nutrient demand depends on the type of crop selected and expected yield. For instance, 180 pounds of nitrogen can be applied to corn yielding 150 bushels per acre, while 325 pounds of nitrogen can be applied to coastal bermuda grass when the expected yield is seven tons per acre. Given the nutrient concentration of treated effluent and crop nutrient demand, a total number of acres receiving

[1] It has been frequently mentioned that manure improves soil characteristics. If long-term productivity boosts or greater drought tolerance could be quantified from increased organic matter, these effects would augment the benefit side of manure value.

manure is determined. Increasing treatment levels and/or per acre nutrient demand decreases total acres receiving effluent. One could fix the total acres receiving effluent and then adjust treatment and/or cropping decisions to accommodate the manure disposal constraints.

For a given volume of manure, manure value is the difference in net returns between the optimal manure utilization plan and the net returns that would have been earned had manure not been present. Specifically, manure value (V_m) is defined as

$$(1) \quad V_m = R(crop) - C(transport) - C(treatment)$$
$$\text{s.t.:} \quad \gamma^H \cdot q(T) \cdot H = N^H$$
$$Q_N^i \leq Q_N^{i*}.$$

The total nutrients produced from a hog operation (N^H) are determined by the average nutrient concentration (γ) and the volume of effluent produced by an operation. The volume produced equals the per head production, $q(T)$, times the number of animals (H). Production per head depends on the length of production cycle (T). The environmental limit (Q_N^{i*}) is a nutrient application rate (i.e., nitrogen loading limit in North Carolina) which equals the agronomic requirement of the ith crop.

Casting equation (1) as a mixed-integer linear programming model, the optimal combination of treatment, acres, and crop type is chosen to maximize crop returns subject to the constraints that manure stocks be exhausted and per acre nutrient loading rates are less than or equal to agronomic requirements. The programming model considers four treatment levels (three lagoon sizes plus a slurry option), two crops (corn and coastal bermuda hay), and irrigation capacity up to 120 acres. Manure volume, which includes flush water, is assumed to be produced at a constant rate of .035 acre-inches per head (Barker 1990). Herd size varies from 600 to 5,400 head.

A stylized version of the mixed-integer programming model is given in table 1. For example, an operation of 600 head would generate 21 acre-inches. The effluent column in the crop irrigation row converges with the treatment column to give the cost of building and maintaining a lagoon that has low treatment (L), medium treatment (M), high treatment (H), or a slurry system (S). For example, 21 acre-inches in the (L) row of crop irrigation would result in a coefficient of 21 in the treatment column. The lagoon cost for (L) would be 21 times the cost per acre-inch. The size of the treatment system also appropriately reduces land available for cropping in the land constraint row. A (0, 1) integer constraint in the effluent block combined with the pick row constraint at the bottom of the table limits the solution to one unique treatment system.

Necessary crop acres for irrigation are determined in the crop acres row(s). Acre-inches from the treatment column are matched to crop production needs for a given treatment and crop. For example, 21 acre-inches from a "low" treatment lagoon contain 1,675 pounds of plant-available nitrogen. Assuming corn and coastal bermuda hay yields of 150 bushels and seven tons per acre, respectively, 9.3 acres of corn and 5.1 acres of bermuda hay are required to meet the disposal and nitrogen loading constraints. Alternatively, 21 acre-inches from a "high" treatment lagoon contain 940 pounds of plant available nitrogen. Consequently, only 5.2 acres of corn or 2.9 acres of bermuda hay are required to receive manure effluent. The crop and acreage are transferred back through the irrigated acres column to the irrigation cost row. Irrigation cost is determined in the transportation column. The transportation column has predefined investment and marginal costs for systems ranging in size from five to 120 acres. Irrigation costs are increasing at a decreasing rate, as determined by Cox. A (0, 1) integer constraint and the pick constraint (second row from the bottom in table 1) limit the solution to the appropriate size. The stylized tableau ignores routine activities such as crop selling in the interest of simplicity. It is solved iteratively for alternative operation sizes and yield assumptions for corn and bermuda hay (low versus high).

Conceptually, manure value can be positive or negative. If it is negative, it can be interpreted as the net disposal cost. In table 2, results under low yield assumptions are given for 600 head (21 acre-inches) to 5,400 head (189 acre-inches) operations. Manure value is always negative, and therefore it is a cost. Per head costs decrease almost 10% (from \$3.73 to \$3.36) as herd size increases from 600 to 5,400, indicating some returns to size. Exogenous variables, including soil quality, ambient climate,

Table 1. Stylized Mixed-Integer Programming Tableau for Treatment, Transportation, and Crop Selection in Waste Management

Item	Effluent Production	Irrig. Acres	Transportation	Treatment	Crop Production		Other Activities[c]	RHS
	L M H S[a]		Sys5 ... Sys120[b]	L M H S	Corn L M H S	B. Hay L M H S	Crop Selling, Commercial Fertilizer	
Units	(0,1)	(acres)	(0,1)	(acre-inches)	(acres)		n/a	n/a
Returns			$-\text{cost}_s$ ... [d]	$-\text{cost}_t$ ...	$-\text{cost}_p$ ...		= crop sales − fert. costs	max
Land				land area_t ...	1 ...			≤ land
Irrig. Acres		−1			1 ...			= 0
Irrig. Cost		1	$-\text{acres}_s$ ...					= 0
Crop Irrig.								= 0
L	− inches			1				
M	− inches			1				
H	− inches			1				
S	− inches			1				
Crop Acres								= 0
L				1	$-\text{NC}_{c,t}$[e] ...	$-\text{NC}_{bh,t}$		
M				1	...			
H				1	...			
S				1	...			
System Pick			1 ...					= 1
Lagoon Pick	1 1 1 1							= 1

[a] L M H S = Low, medium, and high treatment lagoons, and slurry treatments, respectively.
[b] Sys_ = Number of acres requiring irrigation.
[c] For simplicity, crop selling, fertilizer buying, and other ordinary activities are ignored here.
[d] Cost = Cost of irrigating s acres, treating t acre-inches (lagoon/slurry), and variable cost of production per acre (cost_p).
[e] NC = Per acre nutrient content limit in effluent for crop c (corn) or bh (bermuda hay) when using treatment t.

Table 2. Changes in Manure Value Under Low Yield Assumptions

Herd Size (head)	Manure (Q_m) (acre-inches)	Manure Value (V_m) $/Herd	$/Head
0	0	0	0.00
600	21	−2,235	−3.73
1,200	42	−4,404	−3.67
1,800	63	−6,512	−3.62
2,400	84	−8,563	−3.57
3,000	105	−10,565	−3.52
3,600	126	−12,521	−3.48
4,200	147	−14,436	−3.44
4,800	168	−16,318	−3.40
5,400	189	−18,169	−3.36

Notes: Yields were assumed to be 80 bushels and four tons per acre of corn and coastal bermuda hay, respectively. Crop returns were based on prices of $2.50 per bushel of corn, $33 per ton of hay, and input costs of $188 per corn acre and $207 per bermuda hay acre. If manure disposal were not required, land would remain idle. One head is eqivalent to .035 acre-inch.

and prices for crops and inputs, are held constant. Soil quality is assumed to be low so that expected corn and bermuda hay yields are 80 bushels and four tons per acre, respectively. Crop prices are assumed to be $2.50 per corn bushel and $33 per hay ton. Input costs, other than for commercial fertilizers, are $188 per corn acre and $207 per bermuda hay acre (Neuman). Commercial fertilizer prices are based on 1992 averages of $.22, $.25, and $.14 per pound of nitrogen, phosphate, and potash, respectively (U.S. Department of Commerce). Irrigation costs were developed by Cox.

The values reported in table 2 depend on the levels of at least five exogenous variables: corn yield, corn price, commercial fertilizer price, climate, and total manure quantity. Response surface methods (RSM) were used to test the sensitivity of the solution to these exogenous parameters (Khuri and Cornell; Myers). RSM is a sequential process. First, influencing variables are identified, and then a mathematical relationship is estimated between the influencing variables and the dependent variables.

Using the programming model that generated values in table 2, returns to manure utilization were calculated for 43 combinations among the five exogenous variables. The 43 combinations were based on RSM techniques (Roka). Corn price ranges from $1.71 to $3.29 per bushel. Corn yield serves as a measure of soil quality and ranges from 53 to 172 bushels per acre. Fertilizer prices vary 20% above and below 1992 average prices. Regressing the returns to manure utilization against the levels of exogenous variables indicates that the only variables statistically significant are corn yield and total manure stock. Corn and fertilizer prices are not significant variables in determining the level of manure returns. Reestimating a second-order model (RSM) with just corn yield (Y_c) and manure stock (Q_m) yields the following response surface of manure value:

$$(2) \quad V_m = -4608.8 - 164.7Q_m + .088Q_m^2 + 101.9Y_c - .483Y_c^2 + .653Q_m \cdot Y_c.$$

All coefficients are significant at the 5% level. The second derivative of equation (2) is positive, indicating that manure value (V_m) increases with manure volume.

A Market Hog Replacement Model

The previous section showed that manure value is sensitive to the total volume of manure produced by the operation (Q_m). In this section, the response surface estimated by equation (2) is incorporated into a model of animal replacement to examine the sensitivity of market weight decisions from changes in manure value. A swine finishing operation provides a basis for the calculations.

Farm liveweight production depends on the total number of animals as well as their respective weights. The number of animals on a farm site has a direct and obvious bearing on manure stocks. Market or replacement age also has a bearing, though not as obvious. As an animal matures, daily weight gain, feed consumption, and manure output change. As an animal grows bigger, daily manure output increases. Increasing the duration of a production cycle to produce a heavier animal implies younger animals replace older stock at a later age. Therefore, average daily manure output increases. Likewise, decreasing the duration of a production cycle implies an earlier age of replacement with less liveweight produced and lower average daily manure output.

A swine finishing cycle begins when a feeder

pig is placed on a finishing floor. The pig is approximately eight weeks old and weighs between 40 and 50 pounds. During a production cycle, a feeder pig consumes grain and accumulates body weight. Since swine producers are paid on the basis of body weight, the length of a production cycle becomes an important decision variable in the organization of the farm.

It is assumed that growing and finishing hogs are fed optimal feed rations so that an optimal growth trajectory has been predetermined. A producer's replacement decision becomes choosing the number of days on feed (T), which maximizes the following objective function:

$$(3) \quad \pi = (V_p + V_m)e^{-iT} - \int_0^T [r_1 f(t) + r_2]e^{-it}\, dt - I,$$

where π is the discounted value of net returns from a single animal in a swine finishing operation; V_p and V_m are value functions of liveweight and manure, respectively, evaluated after T days on feed; $f(t)$ is the daily quantity of feed consumed; and r_1 and r_2 are unit prices of feed and other variable inputs, respectively. The daily interest rate (i) is approximated by dividing an annual interest rate by 365 days. Initial investment, or feeder pig purchase, is represented by I.

North Carolina swine finishing operations typically are managed under an "all-in/all-out" system. That is, feeder pigs are placed on and removed from a finishing floor as a group. Consequently, a replacement decision for one animal implies a replacement decision for the entire herd.

The optimal marketing (harvest) age is found by differentiating π with respect to T and setting the expression equal to zero. Rearranging terms and simplifying yields the following:

$$(4) \quad \left(\frac{\partial V_p}{\partial T} + \frac{\partial V_m}{\partial T}\right) - i(V_p + V_m) = [r_1 f(T) + r_2].$$

The left-hand side of equation (4) represents the combined marginal value from pork and manure when marketing an animal is delayed one day. The right-hand side denotes the marginal cost of growing an animal one more day.

Solving equation (4) determines the optimal age of slaughter when the operation stops after one rotation. A producer, however, invests in structures and capital equipment which have a productive life beyond the duration of one finishing cycle. When one herd of hogs grows to market weight, the animals are sold and replaced with a corresponding number of younger stock. Optimal time of marketing (T) jointly determines when an older group ends its productive cycle and when a younger group begins. A producer, therefore, is concerned not only with net returns from a single rotation, but also with the expected stream of future net returns from replacement herds.

The objective function [equation (3)] is rewritten as

$$(5) \quad F = \frac{\pi}{(1 - e^{-iT})},$$

where π is defined by equation (3), and F is the discounted value of an infinite stream of future returns. Differentiating F with respect to time and solving for the maximum, yields the following first-order condition:

$$(6) \quad \frac{\partial \pi}{\partial T} - \pi \cdot \frac{i \cdot e^{-iT}}{(1 - e^{-iT})} = 0.$$

The second term in equation (6) represents a "site value" of the fixed plant and equipment associated with a finishing operation. Extending the duration of the current production cycle delays the receipt of income generated from future rotations. As such, it is considered an opportunity cost from delayed marketings.

Livestock Data

Developing a pork revenue function (V_p) requires an estimation of weight at any market time, T. Animal growth literature generally assumes that biological growth follows a sigmoidal shape. In early life, growth rate increases at an increasing rate. As an animal matures and approaches its mature body weight, the growth rate begins to decrease. Bridges et al. estimated the following empirical model that approximates an S-shaped curve:

$$(7) \quad w(a) = WTM\Big(1 - \exp(-m \cdot a^k)\Big),$$

Table 3. Parameter Estimates of Liveweight Growth as a Function of Physiological Age

Parameter*	Estimate
WTM	650 lbs.
k	2.9
TMAX	335 days

Source: Bridges et al.
**WTM* = mature body weight, *k* = a kinetic order of the growth rate function, and *TMAX* = instantaneous age when an animal grows at its maximum rate.

where

$$m = \frac{(k-1)}{k}(TMAX)^{-k}.$$

Animal weight, $w(a)$, is measured at a physiological age, a (days), where age (a) is measured in days from conception, and gestation is assumed to be 114 days. *WTM* represents mature body weight, m denotes an exponential growth decay constant, and k is a kinetic order of the growth rate function. *TMAX* is the inflection point of an S-curve, or the instantaneous age when an animal grows at its maximum rate. Table 3 presents parameter estimates for swine derived by Bridges et al.

A daily revenue function for pork is derived by multiplying predicted weight and a discount adjusted price. A representative market price is taken to be $44 per cwt, and the discount schedule is listed in table 4. Currently, packers consider optimal market weight to be between 220 and 260 pounds. The market determines a unit price of liveweight based on this weight range. Hogs marketed outside this weight range incur a price discount.

Daily manure volume is estimated at any time, t. Expert opinion concludes that daily manure output is proportional to liveweight. The constant of proportionality used in this study is 8.5% of body weight (Barker 1991). Total manure produced by one animal after T days on a finishing floor was

$$(8) \quad q(T) = .085 \int_0^T w(t)\, dt,$$

where $w(t)$ is estimated by equation (7), and t represents the number of days a feeder pig is on the finishing floor. Using the estimated coefficients of equation (7), two levels of manure value were specified—low and high. Low corresponded to poor soil quality (75 bushels per acre of corn) and high manure quantities (189 acre-inches per year). High corresponded to good soil quality (150 bushels per acre of corn) and low manure quantities (21 acre-inches per year).

Representative values for daily feed intake are presented in table 5 (Jones et al.). Both Whittemore and Bridges et al. suggest that a linear model is ade-

Table 4. Price Discount Schedule for Lundy's (Clinton, NC), 16 August 1993

Weight Class (lbs./head)	Lundy's Price Discount ($/lb.)
180–200	−.10
200–220	−.02
220–260	.00
260–280	−.02
280–300	−.035

Note: Assumes a representative market price of $44/cwt and an optimal market weight of 220–260 pounds.

Table 5. Predicted and Representative Swine Growth and Feed Consumption Data for North Carolina by Physiological Age, a (where a = 114 at birth)

a[a] (days)	t[b] (days)	Predicted Weight[c] (lbs.)	NCSU Weight[d] (lbs.)	Average Daily Feed[d] (lbs.)
170	0	57	40	2.6
184	14	71	57	3.5
198	28	87	77	4.2
212	42	104	98	4.8
226	56	123	120	5.4
240	70	144	144	6.1
254	84	166	169	6.8
268	98	189	196	7.8
282	112	214	224	8.8
296	126	239	253	9.2

[a] Physiological age beginning at conception.
[b] Days on a finishing floor.
[c] Predicted by the Bridges et al. model [equation (7)].
[d] Representative weights and feed consumption at selected ages (Jones et al.).

Table 6. Optimal Single Rotation Length of Swine Finishing Operation and Description of Manure Management System by Manure Price Levels

	Single Period				Manure System	
Manure Value Conditions	t (days)	$w(t)$ (lbs.)	π (\$/head)	V_m (\$/head)	Treatment	Crop
$V_m = 0$	137	260	4.36	0.00	n/a	n/a
V_m = high	137	260	1.42	−2.94	low	corn
V_m = low	137	260	0.50	−3.86	high	b. hay

quate to predict daily feed intake quantities. Using values in table 5, daily feed intake is estimated as

$$(9) \quad f(t) = 2.6 + .0524(t),$$

where t represents the number of days on feed.

Unit prices for feed (r_1), other daily costs (r_2), and initial investment are developed from swine finishing enterprise budgets (Zering). Over an assumed 120-day feeding period, an animal grows from 50 pounds to 220 pounds by consuming 550 pounds of feed costing \$32.32, or an average of \$.059 per pound of feed consumed (r_1). A unit price for other daily expenses (r_2) is assumed to be \$.106 per day. This value is derived by assuming other operating expenses (\$12.71) are spread evenly over the production cycle. Initial investment (I) equals the cost of a feeder pig, \$40.

Results

Daily values of weight, manure output, production cost, pork revenue, and manure value were generated using the methods and data described above. As a reference point, optimal production length and market weight of hogs in a finishing operation are determined when manure value is ignored. Then replacement age and market weight are determined under conditions for high manure value and low manure value. A numerical search identifies the value of T which maximized π [equation (4)] for a single period model, and F [equation (6)] for an infinite period model.

When manure value is ignored, profits for a single rotation length are maximized at 137 days or when a hog weighs 260 pounds. For an infinite rotation period, market age is reduced by only one day and two pounds of market weight. Given the values of discounted revenues and costs, a single period profit was \$4.36 per head.

Even under the most favorable conditions, manure value is negative (\$2.94 per head). In other words, the costs of handling manure (treatment and transport) are greater than its benefit as a replacement for commercial fertilizer. Equations (3)–(6) predict that a negative value for manure would induce producers to shorten their production cycles and sell animals at lighter weights. However, the results presented in table 6 show that liveweight herd decisions are not sensitive to manure value. Under the range of manure values considered in this study, animal replacement occurs at 137 days and a weight of 260 pounds.

Some insight as to why replacement decisions are insensitive to manure value can be gained by considering average daily gains in pork revenue versus average daily changes in manure value. Pork revenues increase an average of \$.78 per day (\$107.72/137 days). The cost of handling "high" valued manure (\$2.94 per head) is only \$.01 per day. Clearly, the value of pork dominates a producer's hog marketing decision.

Conclusions

Manure disposal is necessary to maintain the continued operation of a livestock enterprise and is becoming increasingly important as the public scrutinizes the environmental consequences of how it is disposed. Previous studies have implied that manure value is zero and can be ignored when analyzing livestock herd decisions. However, optimal liveweight production depends on the combined value of pork and manure, since a unit of meat production

also increases manure volume. The objective of this study was to carefully consider manure value and measure its sensitivity on liveweight production decisions for a swine finishing operation.

Manure value can be positive or negative depending on the cost to substitute for commercial nutrients. A mixed-integer programming model was constructed to solve manure management decisions in a system that could simultaneously consider multiple management alternatives such as treatment, transportation, and crop type. A sensitivity analysis on herd size, crop type, crop yield, treatment type, and transportation distance yielded consistent costs for manure management. The cost of disposal outweighed the value of contributed nutrients.

Pork production dominated waste management. Even though manure value was negative here, it was small compared to the value of the primary product, pork. Consequently, manure value had no impact on liveweight decisions of market hogs. In addition, since the bulk of irrigation costs are fixed, there were returns to size for manure production. A 5,400-head operation experienced 10% lower costs to dispose of manure than a 600-head operation.

It is important to consider the potential policy implications of manure value. A negative value carries a connotation that manure is a "waste" product. Environmental regulators need to be more vigilant, since a producer's incentive may be to apply excessive manure amounts on land nearest the storage facility. Manure value is determined by farm conditions. Therefore, manure management policies could be improved if they offered flexibility to account for regional diversity to allow producers to maximize the value of their manure resources. This analysis showed that manure could be managed by crop selection, soil quality (which dictates yield), and treatment type.

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