Implications of Structural Change

Contract Production and Industry Productivity

Production contracts offer several potential advantages over independent production that could explain their growing prevalence. Contracts may serve to lower transaction costs associated with search, negotiation, and transfer; reduce differences in the information that producers and processors have about product quality; improve coordination of product delivery; and lower income risk for growers. In addition, contracting may raise farm productivity by improving the quality of managerial inputs, by speeding the transfer of technical information to growers, or by facilitating growers' access to credit, thereby permitting the adoption of newer, more efficient technologies.

However, the recent growth in contracting does not necessarily imply that contracts are associated with higher farm productivity. The use of contracts could potentially lower onfarm productivity if they reduce incentives for growers to work efficiently or to invest fully in specific productive assets. In addition, because contractors and growers share the returns to hog production in contract arrangements, the most productive hog producers may choose not to contract because they can earn higher returns through independent production.

Understanding the link between contracts and farm productivity is crucial to an analysis of the distributive, efficiency, and environmental implications of the recent structural changes in the hog industry, and of policies to regulate contracting. Concerns about the rapid growth in contracting have led to efforts at various levels of government to regulate contract production. These regulations may have significant social welfare costs or benefits, depending in part on how contracting impacts hog farm productivity.

This section discusses potential impacts of contracting on industry productivity and presents research that attempts to identify and measure the farm-level productivity gains, if any, that can be attributed to contracting. To isolate the effect of contracting on farm productivity, differences between farmers who choose to contract and those that do not must be controlled. Contract growers may be more credit-constrained, more risk-averse, and may value autonomy less, or have less managerial or entrepreneurial ability, characteristics that could be correlated with farm productivity. The empirical model used in this research isolates the effect of contracting on farm productivity by controlling for other factors that could also be correlated with productivity. Data from feeder pig-to-finish operations are used to estimate the model. The impact of contracting is measured on 1) partial and total factor productivity and 2) the production technology. Details of the empirical procedure and model results are presented in Appendix II, p. 51. Empirical results identify the determinants of hog farmers' decisions to contract and the factors that influence productivity. Results also shed light on the implications of contracting for the scale of production.

Potential Impacts of Contracting on Productivity

Under the terms of a typical production contract to finish hogs, the contractor provides feed, feeder pigs, veterinary care, managerial assistance, and marketing services. Growers are paid a fee for raising the animals. The feed and other inputs supplied by the contractor represent over 80 percent of the total costs of production. Because contractors supply such a large share of the production costs, contracts drastically reduce the amount of production credit needed by growers. In addition, because a contract reduces price risk, a contract may make it easier for some farmers to obtain financing for setting up or expanding hog production (Boehlje and Ray). Contracting could therefore serve to relieve a binding credit constraint for some growers, freeing them to invest or apply inputs at a more efficient level. On the other hand, because hog production involves large investments in specific assets, contracting may make growers vulnerable to changes in contract terms. If greater investment in specific assets reduces the bargaining power of growers vis-à-vis the contractor, growers may draw back from socially optimal levels of investment, resulting in lower productivity (Shelanski and Klein).

Costs associated with measuring hog quality may result in a difference in the information that producers and purchasers of hogs have about product quality that can affect productivity. If there is asymmetric information about product quality, then farmers have less incentive to invest in raising quality because they may not be fully compensated for this investment by the purchaser (Hennessy). Production contracts that specify the genetic characteristics of the hogs reduce uncertainty about quality. Hence, these contracts can reduce quality measurement costs associated with asymmetric information and may encourage investment in quality (Martinez, Smith, and Zering).

Contractors may also have asymmetric information about the ability of potential growers, which could create a problem for the contractor in selecting among potential growers. Rhodes notes that "in the Corn Belt, their [commercial feed companies and packers] efforts to contract hog production largely subsided within a few years. The better producers were seldom interested in the quasi-employee status that did not provide access to the profits of the good years of the hog cycle." However, another view is that the grower's provision of productive assets (e.g., growing facilities) is an indicator of the grower's ability (Knoeber). Hence, the capital requirement may act as a screening device resulting in the self-selection of growers with greater ability, as these are the producers who are capable of securing the necessary capital.

Findings: Contracting and Productivity

Results showing the impact of contract production on partial and total factor productivity in the hog sector are summarized in figure 19. The impact of contracting was statistically significant for all measures of factor productivity. For an average hog farm, contracting raises feed, labor, capital, other input, and total factor productivity by 36, 44, 16, 52 and 23 percent, respectively. Results also indicate that the impact of contracting on productivity would have been underestimated had the selectivity bias[14] not been taken into account.

Similar results were found in the analysis of the impact of contracting on the production technology. Statistical testing indicates that contract and independent operations were using different levels of technology. An index of technical change constructed from production functions for the contract and independent operations indicates that contracting raises productivity, on average, by about 20 percent. More detail about the results from this analysis is presented in Appendix II, p. 51.

The primary conclusion from these results is that contracting appears to substantially increase the productivity of all inputs used in hog production and total factor productivity. In addition, contracting appears to represent a technological improvement over independent production resulting in significantly more output for an average farm, holding inputs constant. The magnitude of the productivity gains that can be attributed to contracting is striking, and is similar in each of the modeling approaches.

The increases in productivity that result from contracting may be due to an exchange of "know-how" between contractors and growers, which may be particularly important given the relative lack of hog production experience of the contract growers. This information exchange may involve knowledge about feed mixtures or feed timing that results in higher feed productivity and lower labor costs. In addition, it is possible that the goods and services provided by the contractor, such as veterinary care, feed, and especially the genetic quality of the animals, may be superior to those typically used by independent producers, resulting in healthier animals and a more efficient weight gain.

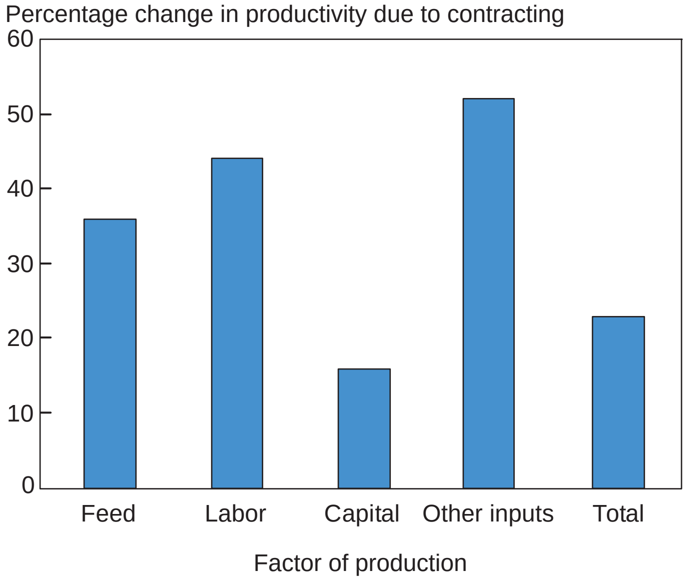
The magnitude of the estimated productivity gains attributable to contracting suggests that improved productivity was likely an important factor in the recent growth in contracting in the hog industry. In addition, contracting may have played a role in the recent increase in the average scale of production. Because contract operations are larger operations, on average, it will be larger operations that enjoy the productivity gains from contracting. Consequently, contracting may serve to enhance the competitive position of larger operations compared with smaller operations.

The higher level of farm productivity associated with contracting implies that policies to regulate or restrict contracting would likely impose economic costs on the industry that could be passed on to consumers. However, negative producer welfare effects (e.g., loss of autonomy) or upstream and downstream costs to contracting (e.g., increased transactions costs) could offset the potential on-

Figure 19

Estimated change in factor productivity from contracting, 1998

Contract hog finishing operations were estimated to have a total factor productivity that was 23 percent higher than independent operations in 1998.



Source: 1998 Agricultural Resource Management Survey.

[14] Selectivity bias occurs because contract growers may differ from independent growers in other ways that may also influence farm productivity. The research model attempts to account for these factors in order to reduce the bias.

farm efficiency gains from contracting. Off-farm or nonmarket costs, such as the environmental impact of an increased concentration of animal waste, may also result because of contracting. Hence, available information is not adequate to quantify the overall benefits and costs to society of policies that restrict contracting.

The Costs and Returns to Contracting

Concern about contract arrangements in the hog industry stems from a perception of increasing market control and power concentrated among packers and large hog operations (Hayenga, Harl, and Lawrence). There is a widespread perception that marketing contract arrangements between packers and large operations insulate large producers from some of the hog price variation in the cash market to which most small independent producers are subjected, and lead to limited market alternatives for independent producers.[15] Also, there are issues associated with contract complexity, grower information and education, and grower risk of significant losses if a particular contractor decides not to renew a contract (Hayenga, Harl, and Lawrence). As contracts become more prevalent and as the hog industry becomes increasingly concentrated, it is possible that large operations could use their stronger bargaining position to extract more of the economic surplus from contract growers. Concerns about the implications of consolidation and the expanded use of contracts in the hog industry have generated calls for legislation to limit packer ownership and control of livestock prior to slaughter, and legislation to protect producers from unfair business practices (Lawrence, Schroeder, and Hayenga; Iowa Department of Justice).

Understanding what impacts the returns to contracting is important for evaluating the policy issues associated with contracting in agriculture. In hog production contract arrangements, the net returns are shared between growers and contractors. Research in this section examines the factors that have affected the success of contractors and growers in these arrangements. Specific objectives of this research are to examine 1) what characteristics of hog contracts, hog operations, and contract participants are important determinants of the contract fees paid, and 2) what factors are associated with the net returns to producing hogs in contract arrangements and how these differ for the contractor and the grower. A better understanding of contract fees and the distribution of returns to contracting is useful for evaluating the impact that various contract design, economic, and human capital factors have had in the success of each party to contracts, and for evaluating the conduct of participants in these arrangements.

[15] However, most large producers sell hogs with marketing contracts that are often tied to the cash market through formula pricing (Lawrence and Grimes).

Distribution of Contracting Costs and Returns

Contract production is an arrangement between a pig owner (the contractor) who engages a producer (a grower) to take custody of the pigs and care for them in the grower's facilities. Each party to the contract provides specified resources used in production, and contractors pay growers a fee for the services they provide. A detailed breakdown of the average costs and returns of contractors and growers in hog finishing contracts, as estimated from the survey data, is shown in table 12. Contractors incurred nearly all the operating costs by providing the feed and feeder pigs, while growers paid for most of the fuel and electricity, repairs, and hired labor. Growers' main costs were the ownership costs associated with the production facilities and equipment, including housing and manure management structures. Gross returns of growers were the fees paid by contractors. Contractors are the residual claimant to the final product, and thus the gross returns of contractors were defined by the value of the finished hogs.

An empirical model of the returns to contracting was estimated in this research. The model was specified by relating several characteristics of contracts and contract participants to the contract fee payments and to the net returns earned by contractors and growers in hog finishing arrangements. The model was estimated using the method of seemingly unrelated regression (Zellner). Details of the model specification, empirical procedure, and model results are presented in Appendix III, p. 57.

Findings: Returns to Contracting

Design of the contract, grower characteristics, age of production facilities, and location of the operation were important determinants of the contract fee payment in hog finishing contracts. Bonus incentives paid as part of the contract resulted in higher contract fees. The monitoring and maintenance of herd health was also associated with higher contract fees and was likely part of the contract incentive structure as payment incentives are often based on performance factors tied to animal health, such as death loss. Greater education and experience by growers, factors likely to enhance the managerial ability and the opportunity cost of engaging in contract production, were also associated with higher contract fees. Location in the South, likely to be associated with lower facility costs and

Table 12—Estimated costs and returns for participants in contract hog finishing arrangements, 1998

Item	Grower	Contractror
	Dollars per cwt gain	
Gross returns:		
Market hogs	0	39.20
Contract fees	5.11	-
Inventory change	0	0.70
Total gross returns	5.11	39.90
Operating costs:		
Feed	0	19.44
Feeder pigs	0	14.87
Veterinary and medicine	0.01	0.20
Marketing	0	0.92
Custom services and supplies	0.08	0.32
Fuel, lubrication, and electricity	0.49	0.03
Repairs	0.26	0.01
Contract fees	--	5.11
Hired labor	0.34	0.00
Operating capital	0.03	0.86
Total operating costs	1.21	41.76
Ownership costs:		
Depreciation and interest[1]	5.53	0.00
Taxes and insurance	0.25	0.02
Total ownership costs	5.78	0.02
Total operating and ownership costs	6.99	41.78
Gross returns less operating and ownership costs	-1.88	-1.86

[1]Computed using the capital recovery method.

lower opportunity costs of contracting, was associated with lower contract fees.

The net returns of both growers and contractors in contract arrangements were largely determined by factors that affect the efficiency of the hog operation. However, these factors impact growers and contractors differently because of the types of inputs provided by each. Growers were responsible for financing and maintaining the investment in production equipment and facilities. Growers had economic incentives for increasing the intensity of facility use in order to spread the fixed facility costs over more units of production. Contractors owned the animals and primarily provided feed and other operating inputs, and sought to improve animal performance through higher quality genetics and other production technologies that maintain herd health and minimize feed and other operating costs. However, growers also benefit from more efficient input use as hogs reach market weight in less time, reducing labor requirements and freeing up facilities that can be utilized more intensely.

Both contractor and grower returns to hog contracting were invariant to size of contracts. This suggests that contractors have not offered large operations more favorable contract terms than smaller operations. In addition, contractors appear to have an incentive to offer contracts to producers with relatively less education. This may result because more highly educated producers have greater off-farm employment opportunities and thus demand a higher wage for contracting. Contractors can offer contracts to producers with less education because contractors provide much of the "how to" knowledge needed to be successful with contract hog production.

The greatest difference between grower and contractor returns from hog contracting arrangements was due to the type of contractor. Integrators had significantly higher returns than did other types of contractors, while growers under contract with integrators had significantly lower returns than did growers under contract with other types of contractors. This could have resulted for several reasons, such as differences in the efficiency of the operations with different contractors and the contract designed by different contractors. Also, the geographic dispersion of contractors and the competitiveness of local markets for contracts could have influenced the contract terms offered in different areas. Integrators provide more services to contract growers, including knowledge about various aspects of hog production. Therefore, integrators are able to provide employment opportunities to producers with relatively less education and experience with hog production, and thus a lower reservation wage for contracting.

An important caveat to this research is that the data used to estimate the empirical model included limited information about hog contractors. The survey sample was of contract growers, which limited the data that could be collected about contractors. Information on the type of contractor was used in the analysis, but information on the size of the contractor's operation, contractors' capital costs, and on the hog marketing methods and strategies used by contractors was not included in the data. These factors would also tend to affect contractors' net returns to hog production.

Manure Management and the Environment

A consequence of the rapid restructuring of U.S. hog production is the waste management challenge posed by concentrating a larger number of animals on a limited land base. The average adult hog produces three times the amount of waste as the average adult person. In Iowa and North Carolina alone, this translates into handling a hog waste volume roughly equal to the sewage from one-third of the U.S. human population (Innes). Rapid expansion and consolidation in U.S. hog production has meant that the responsibility for managing this volume of hog manure has become more concentrated among fewer operations, and the risks of mismanaging manure are magnified.

Among the risks involved with managing hog manure is the potential movement of nutrients into ground and surface water supplies due to leakage, seepage, and/or breakage of storage facilities and the misapplication of effluent to fields. Although limited, evidence does support concerns about these risks. Results from a small sample of lagoons in North Carolina (Huffman) and Iowa (Libra, Quade, and Seigley) showed evidence of localized seepage around storage facilities. Other studies have shown higher nitrate levels in shallow groundwater where excess manure was applied, compared with where manure was applied according to crop requirements (Lorimor and Melvin; Sloan et al.). During the past several years, major lagoon spills or leaks have occurred in Illinois, North Carolina, Iowa, Kentucky, Minnesota, Missouri, Montana, South Dakota, Utah, Virginia, Washington, and Wisconsin (EPA). In June 1995, a lagoon broke in Jacksonville, North Carolina, spilling more than 20 million gallons of sewage into the New River, causing a massive fish kill. Subsequent inspection of more than 4,000 lagoons in North Carolina found 2.8 percent with illegal discharge devices, and another 10 percent with lesser problems (Martin and Zering). Also, a significant amount of public attention has been directed toward offensive odors released from hog barns and manure handling systems. Rural residents have complained that living close to large hog operations has adversely affected the quality of life, and there is some evidence that proximity to large hog operations has lowered surrounding property values (Palmquist, Roka, and Vukina).

It is widely believed that a major reason for the hog manure problem is a lack of adequate land for proper manure application available near the manure source or under the control of the hog producer. The increasing size and consolidation of hog production has meant that farms are more specialized, separating animal production from crop production and cropland. Gollehon et al. found the largest 2 percent of hog farms (those with more than 1,000 animal units) had 35 percent of the national hog production, but controlled only 2 percent of the cropland on hog farms. In contrast, the 36 percent of small farms (those with 50-300 animal units) had 32 percent of the hog production and 45 percent of the cropland. Also, the regional distribution of specialized animal production indicated a much greater separation of hogs and cropland in the Southeast than in traditional production areas of the Corn Belt.

While evidence suggests that many hog operations may not have adequate acreage on which to apply manure, basic economic considerations also suggest that producers may not have an incentive to apply manure properly. This is because transporting manure to distant fields can be costly (Westenberger and Letson), and thus producers can be expected to overapply manure nutrients on fields nearest to the hog production/manure storage facility. Because the additional costs of transporting manure are saved by applying manure close to the facility, producers can be expected to apply more manure nutrients to these fields than would otherwise be applied in chemical fertilizers (Innes). Thus, from an environmental perspective, current incentives for the use of manure can be expected to increase the risk of nutrient runoff and leaching from cropland in the proximity of hog production when compared with the use of commercial fertilizers. Also, manure nutrients have value for crop production only when the farm is growing crops for commercial purposes

Table 13—Characteristics of hog operations by size of operation and region, 1998

Item	50-299 AU	300-999 AU	1,000 AU or more
All hog producers			
Percent of farms	45	12	3
Percent of production	29	33	34
Animal units per farm	131	520	1,980
Percent of farms in AU group			
Heartland	81	66	49*
Southern Seaboard	2	17*	37*
Other regions	17	18*	14*
Percent of farms in region			
Heartland	52	11	2**
Southern Seaboard	15	27	18*
Other regions	32	9*	2**
Heartland			
Arrangement (percent of farms)			
Independent producer	86	64	54
Contract producer	14	36	46
Southern Seaboard			
Arrangement (percent of farms)			
Independent producer	54	6*	5*
Contract producer	46	94	95

Notes: Animal units (AU) are a measure of size used for livestock operations where 1 AU equals 1,000 pounds of live animal weight; percents will not add to 100 due to missing size group (under 50 AU); single (*) and double asterisks (**) indicate a coefficient of variation between 25 and 50, and greater than 50, respectively.

(i.e., for feed or sale). On farms not engaged in commercial crop production, such as on many specialized hog farms, manure management becomes a minimal-cost-disposal issue and spreading manure on nearby land is often the least-cost disposal alternative.

Another issue raised by the rapid structural change in hog production is the liability of managing the hog manure on contract operations. Contract growers have generally held the responsibility for manure management. Most production contracts have required growers to comply with all State, Federal, and local regulations in operating their facilities, while failure to comply can result in termination of the contract (Martin and Zering). Since contract growers have relatively large investments in facilities, they are highly motivated to avoid liability. However, if more stringent regulations increase the cost of manure management, growers may no longer be financially capable of paying the additional costs without assistance from contractors or other sources. Vukina discusses the issues involved with regulating some form of shared responsibility for manure management between contractors and growers.

This section examines relationships between structural characteristics and manure management practices in the U.S. hog industry, describes how potential environmental risks from hog manure vary across the sector, and evaluates the ability of various farm operations to pay for improved manure management. To address these issues, the surveyed hog operations were divided into size groups according to the estimated number of animal units (1 AU=1,000 pounds of liveweight) on each operation: (a) 50-299 AU, (b) 300-999 AU, and (c) 1,000 AU or more. The two largest size groups, operations with 300 AU or more, were specified to include those operations most likely regulated as Concentrated Animal Feeding Operations (CAFOs) by EPA (Lovell and Kuch; see Glossary, p. 43). Regional differences in manure management issues were examined by contrasting the situations in the Heartland and Southern Seaboard. Differences in manure management technologies, manure application and crop production, and farm financial performance were examined. The ability to pay for improved manure management was also contrasted by size of operation and for contract and independent operations. All surveyed hog operations, regardless of type, were included in this analysis.

Only 3 percent of hog operations had 1,000 AU or more in 1998, but these operations were responsible for about one-third of hog production (table 13). Another 12 percent of operations had 300-999 AU and provided another third of production. The largest facilities averaged nearly 2,000 AU, equivalent to about 8,000 head of finished (250-pound) hogs. More than 85 percent of farms with 1,000 AU or more were in the Heartland and Southern

Table 14—Manure management technologies by size of operation and region, 1998

Item	(a) 50-299 AU	(b) 300-999 AU	(c) 1,000 AU or more
Heartland			
Storage facilities (percent of farms)			
Lagoons	19*[bc]	35*[ac]	66*[ab]
Pits or tanks	60*[c]	62*[c]	34*[ab]
Manure handled (percent of manure)			
Solid	36*[bc]	8*[a]	2[a]
Percent incorporated	5	4*	24
Liquid	63*[bc]	91*[a]	98[a]
Percent incorporated	47*[b]	74*[a]	68*
Equipment used (percent of farms)			
Liquid spreader	73*[c]	81*[c]	47*[ab]
Sprinkler irrigation	8*[bc]	18*[a]	28*[a]
Manure tested (percent of farms)			
N content	14*[bc]	39*[ac]	68*[ab]
P content	14*[bc]	39*[ac]	68*[ab]
Other practices (percent of farms)			
Moved manure off operation	17[bc]	41*[a]	46*[a]
Manure given free of charge	16[bc]	30*[a]	43*[a]
Southern Seaboard			
Storage system (percent of farms)			
Lagoons	83[bc]	98[a]	98[a]
Pits or tanks	1	id	id
Manure handled (percent of manure)			
Solid	1	id	9
Percent incorporated	15[bc]	id[ac]	id[ab]
Liquid	93	99	91
Percent incorporated	14	15[c]	7[b]
Equipment used (percent of farms)			
Liquid spreader	8	6	5
Sprinkler irrigation	93	100	99
Manure tested (percent of farms)			
N content	69[bc]	96[a]	99[a]
P content	69[bc]	90[a]	96[a]
Other practices (percent of farms)			
Moved manure off operation	7	3	1
Manure given free of charge	7	2	1

Notes: * Indicates estimate is significantly different from Southern Seaboard estimate (90-percent level); *a,b,c* indicates estimate is significantly different from size group listed (90-percent level); id means insufficient data for legal disclosure.

Seaboard regions. Within the Southern Seaboard, 18 percent of farms had 1,000 AU or more, and an additional 27 percent of farms had 300-999 AU. In contrast, only 2 percent of Heartland farms had 1,000 AU or more and another 11 percent had 300-999 AU.

Contract production arrangements were used significantly more often on farms with 300 AU or more in both regions and across all sizes on Southern Seaboard farms. More than 90 percent of operations with 300 AU or more were operating under contract business arrangements in the Southern Seaboard, compared with less than half of the operations in the Heartland.

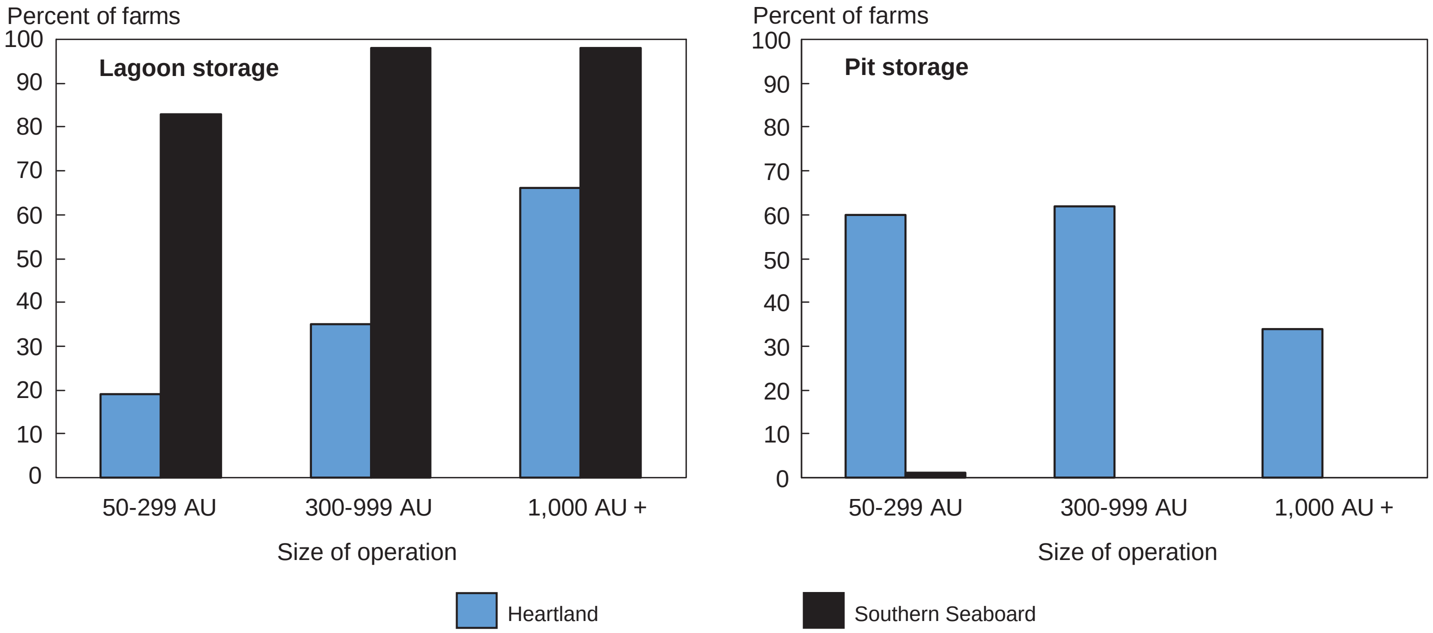
Manure Management Technologies

Hog manure management technologies (facilities and practices) used on the different size of operations in each region are shown in table 14. The use of manure storage facilities differed substantially between the regions (fig. 20). Significantly more producers used pit storage in the Heartland than in the Southern Seaboard, where lagoons were used by more than 80 percent of operations in each size group. Also, lagoon storage was more common in the Heartland on operations with 1,000 AU or more than on smaller operations. Pit storage retains much more of the manure nutrient value than does lagoon storage. Lagoon storage is generally more cost effective on large opera-

Figure 20

Regional distribution of manure storage facilities by size of operation, 1998

Lagoons were used by more than 80 percent of Southern Seaboard operations in each size group, while pit storage was used more often on Heartland operations.



Source: 1998 Agricultural Resource Management Survey.

tions and serves as a treatment system when acreage for manure disposal is limited, because more of the nitrogen is volatilized into the atmosphere.

Most manure in both regions was handled in liquid form, but manure application systems differed sharply in each region. Most Heartland operations used a liquid spreader to transport manure from storage to the field. More than two-thirds of the liquid manure from operations with 300 AU or more in the Heartland was incorporated into the soil (either by injection or tillage operation) at application, compared with less than 15 percent of manure on those operations in the Southern Seaboard. Incorporating manure at application is a practice that reduces nutrient volatilization, making more nutrients available for plant uptake, and reduces the risk of nutrient runoff. Nearly all Southern Seaboard operations in each size group used sprinkler irrigation technology to move and apply lagoon liquid. Sprinkler application increases nitrogen volatilization, which reduces the nitrogen available for plant use relative to other manure application methods. The lagoon/sprinkler system is designed to allow producers to dispose of the manure from a given operation on fewer acres when a nitrogen criterion is used to determine appropriate application levels.

The larger operations in both regions were more likely than smaller operations to monitor the manure nutrient content through testing, a practice required as part of many State-mandated manure management plans, particularly among States in the Southern Seaboard (table 14). Heartland operations of 300 AU or more were more likely to dispose of manure by moving it off the operation for use on other operations. More than 40 percent of these operations reported that hog manure was removed from the operation, with the majority of these farms giving the manure away free of charge. This practice was rarely used in the Southern Seaboard and is likely influenced by differences in the manure handling technologies used in each region. Manure handled with the lagoon/sprinkler technology has much less applied nutrient value and the effluent is more difficult to move to outlying fields or neighboring farms than manure handled with the pit/spreader system. Heartland producers also may have had more crop farms nearby on which to apply the manure than did producers in the Southern Seaboard.

Manure Application and Crop Production

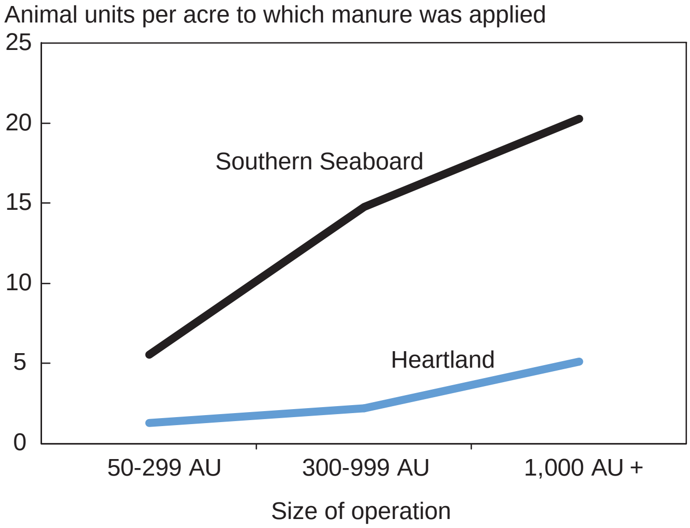
The acreage used for manure application and total crop production increased with operation size, but so did the concentration of animals on the land base (table 15). The actual intensity of manure application is the ratio of animal units to acres on which manure is applied.[16] This ratio provides a measure across size groups and regions of the relative difficulty that these farms would have in meeting policies that require agronomic rates of manure application.[17] In the Heartland, the ratio ranged from 1.28 AU per acre among operations with 50-299 AU to 5.14 AU per acre among operations with 1,000 AU or more. Producers in the Southern Seaboard applied manure to fewer acres and the actual intensity ratio was significantly higher than in the Heartland for all size groups, rising from 5.55 AU per acre to 20.30 AU per acre from the smallest to the largest operations (fig. 21).

Potential intensity of manure application, measured as the ratio of animal units per total crop acre, can be regarded as an indicator of the extent to which producers could alter practices to reduce manure application rates on the existing land base. This ratio was much lower than the actual application ratio, ranging across size groups from 0.24 to 1.20 AU per acre in the Heartland, and 0.62 to 4.73 AU per acre in the Southern Seaboard. The actual and potential intensity ratios likely differ because of factors such as cropping patterns, manure management technologies, and the distance from storage facilities to farm fields. The coverage ratio indicates the percent of total crop acres to which manure was applied, running 30 percent or less in all cases. This means that producers were not applying manure on 70 percent or more of their crop acreage. Liquid hog manure is expensive to transport, and it appears likely that producers minimized the distanced hauled by spreading mainly on fields close to manure storage. Also, the lagoon/sprinkler technology used on many operations limits the ability to move manure long distances without a significant additional investment.

Manure nutrients pose less environmental risk if applications are balanced by crop utilization. Crops grown on hog operations in the Heartland varied little across size groups and included mainly corn and soybeans, accounting for about 90 percent of the crop acreage in each group. The crop mix on Southern Seaboard farms also varied little by size, but the crop mix was more varied than in the Heartland with significantly more acreage in other field crops (e.g., cotton), small grains, and forage crops, and less acreage in corn and soybeans. Forage crops tend to have higher nutrient uptake rates than field or small grain crops.

Figure 21
Concentration of hogs on the land base by operation size, 1998

The concentration of hogs on the farmland area increased with size of operation, but was significantly greater in the Southern Seaboard than in the Heartland.



Source: 1998 Agricultural Resource Management Survey.

The animal and acreage data were also used to estimate actual and potential manure nitrogen loading rates by size of operation and region.[18] The distribution of farms by nitrogen loading levels, using both the actual and potential acreage levels, are presented in table 15. Most field crops utilize nitrogen in the range of 100-299 pounds per acre. Nitrogen rates of 300 pounds per acre or more are above the utilization rate of most field crops and are more in the range suitable for forage crops. Larger operations applied more nitrogen per acre than smaller operations in both regions. About one-third of Heartland producers with 300 AU or more applied manure nitrogen at a rate of 300 pounds or more per acre. In contrast, three-fourths of Southern Seaboard producers with 300-999 AU and more than 90 percent with 1,000 AU or more applied 300 pounds per acre or more of nitrogen. If manure was spread on all cropland (potential N rate), the percentage of large Heartland farms loading nitrogen at a rate of 300 pounds or more per acre falls to just above 10. However,

[16] In computing the production intensity ratios for farms that moved manure off the operation, the number of AU was reduced by the equivalent amount of manure removed. For example, if 50 percent of the manure was moved off a 1,000 AU operation, only 500 AU was used to compute the ratio. This gives a better estimate of the AU being supported by the land base.

[17] Agronomic nutrient rates depend on type of crop, crop yield, soil nutrients, and other factors. Gollehon et al. reported national average agronomic ratios of 1.1 AU per acre for nitrogen and 0.25 AU per acre for phosphorus, although these may not be comparable across all confined animal types.

[18] Per acre nutrient loading was estimated using secondary data on manure production and nutrient content, with appropriate adjustments for nutrient losses due to alternative storage, treatment, and application methods (Moore).

Table 15—Manure application and crops produced by size of operation and region, 1998

Item	(a) 50-299 AU	(b) 300-999 AU	(c) 1,000 AU or more
Heartland			
Acres to which manure was applied	96*[b]	186*[a]	194*[a]
Total crop acres	524*[b]	685*[a]	829*[a]
Coverage ratio (percent of crop acres)	18*	27	23
Production intensity:			
Actual intensity (AU/applied acre)	1.28*[c]	2.20*[c]	5.14*[ab]
Potential intensity (AU/crop acre)	0.24[bc]	0.60*[ac]	1.20*[ab]
Crops produced (percent of crop acres):			
Corn grain	48*	48*	45*
Soybeans	41	43*	42*
Other field crops	id*	1*	1*
Small grain crops	4*	4*	7*
Forage crops	7[c]	4*	4*[a]
Actual N loading (percent of farms)			
100-299 pounds per acre	42	30	27
300 pounds per acre or more	14*[bc]	31*[a]	36*[a]
Potential N loading (percent of farms):			
100-299 pounds per acre	3*[bc]	18[ab]	33[bc]
300 pounds per acre or more	id*[bc]	12*[a]	11*[a]
Southern Seaboard			
Acres to which manure was applied	31[c]	38[c]	96[a,b]
Total crop acres	281	128[c]	410[b]
Coverage ratio (percent of crop acres)	11[b]	30[a]	23
Production intensity:			
Actual intensity (AU/applied acre)	5.55[bc]	14.81[ac]	20.30[ab]
Potential intensity (AU/crop acre)	0.62[bc]	4.45[a]	4.73[a]
Crops produced (percent of crop acres):			
Corn grain	22	22	18
Soybeans	25	30	30
Other field crops	27	16	15
Small grain crops	13[c]	11[c]	20[ab]
Forage crops	11	19	17
Actual N loading (percent of farms):			
100-299 pounds per acre	39[bc]	21[ac]	7[ab]
300 pounds per acre or more	29[bc]	75[ac]	92[ab]
Potential N loading (percent of farms):			
100-299 pounds per acre	29	21	29
300 pounds per acre or more	18[bc]	58[a]	54[a]

Notes: * Indicates estimate is significantly different from Southern Seaboard estimate (90-percent level); *a,b,c* indicates estimate is significantly different from size group listed (90-percent level).

more than half of farms in Southern Seaboard with 300 AU or more would still be loading 300 pounds per acre or more of nitrogen.

Paying for Manure Management

The ability of operations of different sizes and types to pay for manure management is an indicator of what might happen if regulations increased the cost of manure management. Farm financial performance, including farm income statement and balance sheet information, is presented in table 16 by size of operation and region. Net cash and net farm incomes[19] increased by size of operation in each region, but were substantially greater for farms with 1,000 AU or more than for other farms. In the Heartland, net cash farm income was nearly $500,000 among the largest farms compared with less than $70,000 among the other farms, while net farm income was more than $300,000 versus only about $20,000. Similar differences were measured in the Southern Seaboard where net cash income was nearly $275,000 on farms with 1,000 AU or more compared with less than $70,000 on other farms.

[19] Net cash farm income is the difference between gross cash income and cash expenses. Net farm income is computed as net cash farm income less expenses for depreciation and noncash labor benefits, plus the value of inventory change and noncash income.

Table 16—Financial performance of hog farms by size of operation and region, 1998

Item	(a) 50-299 AU	(b) 300-999 AU	(c) 1,000 AU or more
Heartland			
Farm income statement (dollars/farm)			
Gross cash income	230,205[bc]	444,297*[ac]	1,760,599*[ab]
Cash expenses	180,344[bc]	375,393*[ac]	1,278,836*[ab]
Net cash farm income	49,861[c]	68,904[c]	481,763*[ab]
Net farm income	21,034[c]	14,489[c]	319,219*[ab]
Farm balance sheet (dollars/farm)			
Assets	764,220[bc]	1,252,370*[ac]	2,963,233*[ab]
Liabilities	176,508[bc]	393,733*[ac]	1,269,486*[ab]
Equity	587,711[bc]	858,637[ac]	1,693,747[ab]
Debt-to-asset ratio	0.23[bc]	0.31*[ac]	0.43[ab]
Return on equity (percent)	3.58[c]	1.69[c]	18.85[ab]
Southern Seaboard			
Farm income statement (dollars/farm)			
Gross cash income	204,227[c]	193,152[c]	729,275[ab]
Cash expenses	184,339[c]	123,746[c]	454,596[ab]
Net cash farm income	19,889[bc]	69,406[ac]	274,679[ab]
Net farm income	-15,299[c]	29,022[c]	155,864[ab]
Farm balance sheet (dollars/farm)			
Assets	801,474[c]	886,801[c]	2,000,288[ab]
Liabilities	122,530[c]	181,915[c]	589,423[ab]
Equity	678,945[c]	704,886[c]	1,410,866[ab]
Debt-to-asset ratio	0.15[c]	0.21	0.29[a]
Return on equity (percent)	-2.25[c]	4.12[c]	11.05[ab]

Notes: * Indicates estimate is significantly different from Southern Seaboard estimate (90 percent level); *a,b,c* indicates estimate is significantly different from size group listed (90 percent level).

Net farm income was over $150,000 on the largest farms, about $30,000 on farms with 300-999 AU, but negative for farms with 50-299 AU.

The balance sheet data indicate much higher asset, debt, and equity levels on the largest farms in both regions. Farms with 1,000 AU or more had asset levels over $2 million in 1998 and about $1.5 million in farm equity. These farms were generally more highly leveraged than other farms with a debt-to-asset ratio of more than 0.4 in the Heartland and near 0.3 in the Southern Seaboard. However, the return on equity during 1998 was significantly higher on farms with 1,000 AU or more than on other farms, running at over 18 percent in the Heartland and over 11 percent in the Southern Seaboard.

Despite similar trends across the size groups in each region, there are significant differences between regions in terms of the income, asset, and debt levels for operations with 300-999 AU and 1,000 AU or more. These differences are due mainly to the type of business arrangements that predominate in each region, with more independent producers in the Heartland and more contract operations in the Southern Seaboard. The financial performance data for contract operations exclude contractor resources and income. Thus, the income from hog production is the contract fee paid to the contract grower, and the assets and debt are also the grower's. Table 17 includes a comparison of the financial performance data for contract and independent operations for the 1,000 AU or more and 300-999 AU size groups. In both size groups, the net farm income on contract operations is only about one-third of the net farm income on independent operations. Contract producers also have significantly less equity in the operation and are carrying significantly higher debt relative to assets.

Findings: Industry Structure and Manure Management

The data indicate that manure management technologies, potential environmental risks, and farm financial performance vary substantially with size and location of operation across the hog industry. Among manure management technologies, two systems predominate. One system handles liquid manure using pit storage, mostly under hog buildings, and uses slurry spreaders to move the manure from storage to fields and injects the manure into the soil. This system manages the manure for its potential nutrient value as fertilizer and is used more often on Heartland farms and on smaller operations. Because this system is

Table 17—Financial performance of hog farms by business arrangement and size of operation, 1998

Item	Contract operations	Independent operations
1,000 AU or more		
Farm income statement ($/farm)		
Gross cash income	597,833*	2,877,859
Cash expenses	364,791*	2,199,785
Net cash farm income	233,092*	678,074
Net farm income	140,677*	502,716
Farm balance sheet ($/farm)		
Assets	1,914,542*	3,676,888
Liabilities	876,259	1,306,058
Equity	1,038,284*	2,370,830
Debt-to-asset ratio	0.46*	0.36
Return on equity (percent)	13.55*	21.20
300-999 AU		
Farm income statement ($/farm)		
Gross cash income	221,348*	566,221
Cash expenses	165,431*	490,667
Net cash farm income	57,917	75,555
Net farm income	7,592*	25,328
Farm balance sheet ($/farm)		
Assets	883,836*	1,483,828
Liabilities	332,421	381,589
Equity	551,415*	1,102,239
Debt-to-asset ratio	0.38*	0.26
Return on equity (percent)	1.38	2.30

Notes: * Indicates estimate is significantly different from independent operation estimate (90-percent level).

designed to retain manure nutrients for subsequent crop use, more land is needed to apply manure. However, because the manure potentially has more value as a nutrient source and because it is transported in slurry spreaders, manure can be more readily moved off the operation. The other predominant system handles liquid manure in lagoon storage and uses a sprinkler irrigation system to spread manure. This system manages manure more for disposal than nutrient value and is used more often in the Southern Seaboard and on larger operations. Because the manure is treated to reduce nutrient content by increasing the volatilization of nitrogen into the atmosphere, less land is needed to apply manure. Sprinkler delivery directly from the lagoon also limits the distance the manure can be transported, thereby restricting manure spreading to fields close to the facility and restricting the ability to move manure off the operation.

Significant disparities in the land base concentration of hog operations were measured across size groups and regions. The data suggest that the potential for excess nutrients from hog operations is much higher in the Southern Seaboard than in the Heartland, and among larger versus smaller operations. Even though large Southern Seaboard operations used technologies to minimize manure nutrient content, about three-fourths of operations with 300-999 AU and nearly all operations with 1,000 AU or more had nitrogen loading rates from manure at 300 pounds per acre or more. About one-third of Heartland operations with 1,000 AU or more applied manure nitrogen at 300 pounds per acre or more. Given the crop mix on farms in these groups, it is likely that that nitrogen loading rates from manure applied on the farms' land matched or exceeded the utilization capability on many farms. This means that proposed guidelines to base manure applications on the most limiting of nitrogen and phosphorus would require significant changes in the way manure is managed on many farms, particularly large farms and farms in the Southern Seaboard.

One strategy for dealing with tighter regulations on manure management is to spread manure over more acreage. These data suggest that many hog producers have a significant potential for spreading manure over more crop acreage on their farms. In none of the cases examined was manure applied on more than 30 percent of available crop acreage, so nutrient loading could be significantly lowered by spreading on more farm acreage. However, the lagoon/sprinkler technology used to handle manure on many Southern Seaboard operations may restrict the ability to spread manure over more acreage. Also, more than half of Southern Seaboard operations with 300 AU or more would still be loading nitrogen at extreme levels of crop utilization if manure were spread over all available acreage. With the available acreage and manure management technologies used on Heartland farms, this strategy appears to be a much more feasible approach to dealing with any new restrictions. However, the additional costs of spreading manure over more farm acreage would reduce the economic performance of the hog operation.

An alternative for dealing with tighter regulations is to invest in alternative or innovative manure management technologies, such as new treatment facilities. Results of the financial analysis in this study indicate that operations with 1,000 AU or more have net income and equity levels that place them in a much better position than smaller operations to make the necessary capital investments required with these systems. Economies of size in hog production would allow these large operations to spread the fixed investment over more units of output. Farms with less than 1,000 AU had less than a fourth of the cash income and half the equity that the larger operations had. Also, the potential environmental risk from hog production was greatest in the Southern Seaboard region, where contract production is predominant. The relative financial position of contract growers indicates that they are less able than independent producers of the same size to afford additional capital investments. Manure management restrictions thus have the potential to influence the structure of hog production.