Environmental policy influences on livestock stocking and location decisions

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Abstract

This paper explores the relationship between state level environmental regulations and stocking and location decisions in the U.S livestock and poultry industry (beef, chicken, dairy and hogs). Rather than conduct this analysis on a species-by-species basis, we choose to focus upon the overall size of the livestock industry (expressed in animal units) and the size of industry found on large, medium and small operations by state (48) and over time (28 yrs). Results indicate that industry may drive policy rather than the converse. However, since we also find that existing policy rules have differential impacts on the industry by operation size, we conclude that structural change in the industry may be driven in part by size or legal structure discriminating regulations.

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1. Environmental policy and the livestock and poultry industries

Since the enactment of the 1972 Clean Water Act (CWA), industries potentially creating point sources of water pollution have been required to obtain National Pollutant Discharge Elimination System (NPDES) operating permits. With the revision of the CWA in the mid-1980s, livestock operations of greater than 1,000 Animal Units (AU), as well as smaller operations found in environmentally sensitive locations, were also subject to federal regulation. Currently, 43 states have been granted enforcement authority of NPDES permits by the EPA.

State and local concerns surrounding the environmental management of livestock operations have created a mosaic of state level environmental policy milieu. In 1998, 23 states and the federal government considered legislation to more closely monitor emissions from livestock operations (Edelman et al). Environmental policies applied to livestock generally are directed toward larger, incorporated, or vertically integrated operations (Martin & Zering; Hubbell; Metcalfe). These policies tend to address ground and surface water concerns and, increasingly, air quality issues.

Livestock industry structure also has undergone recent measurable change. The average size of livestock operations has changed substantially (Table 1). Since 1970, a consistent downward trend in the number of livestock found on farms of size smaller than 300 Animal Units (AU). This trend was most pronounced in the late 1980s, following a short period of growth in the category. The number of livestock on operations between 300 AU and 1000 AU generally increased during the 1970s and 1990s and decreased during the 1980s. The number of livestock found on operations greater than 1000 AU in size climbed steadily through the late 1980s and accelerated into the early 1990s. In 1994, the number of animals on large operations began a relatively strong decline that has persisted through the end of our time series (Table 1).

Table 1. Annual percent change in number of animal units found on livestock operations, by operation size (%)

Year	Small Operation	Medium Operation	Large Operation
1970	-0.24	7.08	1.92
1972	-0.24	6.21	1.84
1974	-0.24	5.52	1.78
1976	-0.13	-0.53	7.80
1978	-0.13	-0.54	6.75
1980	7.13	1.69	-0.89
1982	6.24	1.64	-0.91
1984	-8.19	-2.63	2.68
1986	-9.79	-2.78	2.54
1988	-1.38	2.83	25.67
1990	-1.42	2.68	16.96
1992	-1.46	2.54	12.67
1994	-2.73	0.14	-4.67
1996	-2.89	0.14	-5.15

Source: Census of Agriculture, 1997. Small Operation = < 300 AU. Medium Operation = 300-1000 AU. Large Operation = >1000 AU.

Technological innovation and lower transportation costs have increased location alternatives and firm/industry structure decisions by weakening the geographic link

between feed supplies and livestock. Structural change, including the dramatic trend toward fewer, larger, segmented, and integrated operations, is evident across livestock species. For example, in 1988 the average hog operation was a 200 head farrow-to-finish operation. In 1997, the analogous statistic was a 550 AU farrow, nursery, or finish operation. Nationwide, the average size of beef cattle operations has increased 71%, from 35 to 95 head per operation and poultry operations have grown 82%, from 2,327 to 4,224 birds per operation within the last decade. In 1972, 17% of all broilers were processed by four firms (i.e., Tyson Food, Goldkist, Perdue and Conagra). In 1994, these firms processed more than 40% of all broilers (Watts and Kennett).

For a livestock operation, location and stocking decisions largely are determined by access to input and output markets, management technology employed and the environmental attributes of the land. It has been hypothesized that the stringency of environmental regulations either (a) drives or (b) is the catalyst for change in (location, size, species composition, legal structure) livestock industry stocking and location decisions (Mo & Abdalla; Martin & Norris). Alternatively, the willingness and ability to enforce these regulations may affect location and stocking decisions. Policy, location and stocking decisions may affect or be driven by operation size or livestock species or may be due to a cumulative effect of all livestock operations or stock of animals. Although policy debates over the environmental management of the livestock industry are prominent in public discourse, little empirical evidence testing these hypothesized relationships is found in the literature.

Here, the state level (48 states) effects of environmental policy across livestock and poultry species (i.e., hogs, beef cattle, dairy, and chickens) over the almost three

decades since the passage of the CWA are examined. The similarities and distinctions of the influence of state level environmental policies on livestock stocking and location decisions by operation size are explored, reflecting the pervasive regulatory approach. The letter of the law and indicators of the willingness to enforce it are differentiated. Changes in stocking rates and operation profiles are expected to reflect the imposition of new environmental policies. The stringency of environmental regulation coupled with the willingness to enforce (i.e., highest average compliance costs) is expected to most strongly guide the evolution of the livestock industry when location factors are most open.

2. Published approaches and evidence

Although a substantial body of research relates location decisions of manufacturing firms to environmental policy, the literature specifically relating environmental policy to the livestock industry is fairly thin. Persistent challenges in compiling appropriate data and attendant analytical difficulties have contributed to the lack of published research-based information. Rather than enter the debate over whether large confined animal feeding operations are “farms” or “factories,” we draw insights from the broader literature base.

2.1 Environmental policy and manufacturing

The manufacturing sector literature conveniently divides into two categories: surveys of manufacturers regarding factors they consider in plant location; and secondary analyses of characteristics theoretically presumed to affect firm location (Mo & Abdalla). Industries studied include: plants of Fortune 500 manufacturers (Bartik, 1988);

automotive plant location (McConnell & Schwab); all industries falling under ozone regulations (Henderson); and the pulp and paper industry (Gomez et al). Analytical techniques include: microeconomic conditional logit specifications (McFadden; Bartik, 1988; McConnell & Schwab; Levinson; Gray); a microeconomic fixed effects model of panel data (Henderson); and a macroeconomic stationary Markov chain model (Gomez et al).

Most results suggest that geographic environmental policy variation has little effect on plant location (Bartik, 1988; McConnell & Schwab; Levinson), potentially due to low expected compliance costs. However, evidence of negative correlation between the stringency of environmental policy and plant location decisions has been shown in some cases (Henderson; Gray) and one study (Gomez et al) shows that plant capacity decisions influenced by the policy environment.

2.2 Environmental policy and the livestock industry

Unlike analyses of the manufacturing sector, most research on livestock is industry (species) specific. Taken as a body of research, the results are inconclusive. Thurow and Holt find that the timing and sequencing of policy signals influence compliance behavior and options for Texan and Floridian dairies; policy influences decision-making. Mo and Abdalla were unable to find a significant relationship between hog farm location and stocking decisions and environmental policy stringency in the 13 leading hog producing states. Martin and Norris summarize previous work on environmental policy and livestock industry structure and conclude that it is more likely that industry drives policy rather than the converse.

Metcalfe extends Mo and Abdalla to include four policy stringency indices, expand the number of states (to include the 27 most important hog producing states), and increase the length of the time series (1984-1998). The potential endogeneity of environmental regulations and hog production decisions is incorporated, addressing Martin and Norris observation. Metcalfe fails to establish the link between policy stringency and firm location decisions and concludes that environmental regulation has no measurable influence on hog production decisions. However, traditional factors including corn price, transportation costs and agricultural infrastructure were significant predictors of hog production and location decisions (Metcalfe).

3. Data and analytical approach

3.1 Approach

A pooled common-effect Generalized Least Square (GLS) model with cross sectional weighting of panel data was used to investigate the hypothesis of whether state level environmental policy stringency and enforcement efforts influence the total size of the livestock industry or of its operations in a state. Random (Davidson & Mackinnon) and fixed effects (Kmenta) models were systematically discarded due to a near singular matrix and temporally invariant environmental policy variables, respectively. The general GLS model is:

$$Y_{it} = b_1 + b_k \sum_{k=1}^{K} X_{itk} + U_{it}$$

The dependent variable (Y_{it}) is specified as total animal units in a state in a given year. The matrix of independent state characteristic variables (X_{itk}) consists of two

principal categories: Following Mo and Abdalla, the independent variables were organized into Natural Endowments (1), Economic Factors (3), Business Climate (3) and; and the stringency of state environmental policy (5). Both the breadth (48 states and 4 livestock species) and depth (30 yrs) of previously published work are extended in this analysis.

It is assumed: all coefficients are constant for all states; the error term for given state follows a first-order autoregressive process; the variance of the error can vary across states; and the estimation error across states is contemporaneously correlated (Judge et al). An advantage of this model is that degrees of freedom are not lost. Due to the policy variable, we assume that intercepts and slopes are the same for all individuals, even though the behavior of the disturbances over the cross-sectional unit (state) is likely to be different from the behavior of the disturbances of a given cross-sectional unit over time (Kmenta). Results are discussed in aggregate terms and in terms of estimated influences across operation size categories.

3.2 Data compilation and manipulation

The data compiled for this analysis include animal inventory and number of operations by size, livestock species, and state over time. As a dependent variable, secondary data (Census of Agriculture, 1997) were compiled from all 50 states for dairy, swine, beef cattle and broiler industries almost three decades (1969 to 1997). Data sources, units and variables are summarized in (Table 2).

Annual state total animal inventory was calculated using animal unit equivalents. EPA standards were used and dry systems were assumed for poultry operations.

Inventory per operation was segmented into three size categories broadly based upon federal policy norms to the extent that data allowed.

Table 2. List of Variables in the Analysis

Variable	Units	Abbreviation	Sources
Inventory – Beef	Thousand head	Binven	Census of Ag, 1997
- Chicken		Cinven	
- Dairy		Dinven	
- Hog		Hinven	
Total Animal Units	Thousand AU	Anitot*	Census of Ag, 1997
		AnitotG1-G3**	Census of Ag, 1997
Animal-Corn Price Ratio -Beef		Bratio(B/C)	
- Hog		Hratio(H/C)	
Slaughtering Capacity - Beef	Lbs	Bslaught	Census of Ag, 1997
- Hog		Hslaught	
Land Value	$/acre	Landval	Census of Ag, 1997
Unemployment Rate		Unemp	Census Bureau, 1997
Animal Density - Beef	Head/ Thousand acres	Bexist	Census of Ag, 1997
- Chicken		Cexist	
- Dairy		Dexist	
- Hog		Hexist	
Annual Average Precipitation	Inch	Precipt	Census of Ag, 1997
Property Tax	$/acre	Protax	Census of Ag, 1997
State Regulation Stringency Index	(0, 1, …, 19)	Regula	Task Force Survey
Fines Imposed	(0,1)	Levfine	Task Force Survey
Staffing Level	(FTEs)	Staff	Task Force Survey
Anti-Corporate Farm Law	(0,1)	Corp	Task Force Survey
Local Zoning Ordinances	(0,1)	Zoning	Task Force Survey

Note: Anitot = Binven × 1 + Hinven × 0.4 + Cinven × 0.001 + Dinven × 1.4. Anitot G1, G2 and G3 are small (<300AU), medium (300-1000AU) and large (>1000AU) operations, respectively.

The environmental regulation factors were based upon the "1998 National Survey of Animal Confinement Policies" database containing information from 48 states (Louisiana and West Virginia chose not to respond). A proxy variable (Regula) was constructed to represent the general stringency of state regulations using this survey information. The index was constructed as an unweighted sum of affirmative responses to twenty-nine regulatory stringency-related survey questions.

Neither active enforcement (fines imposed over time or evidence of compliance with policies) nor effectiveness (changes in water or air quality) measures are currently available in a form usable for this analysis. As imperfect substitutes for enforcement information, a dummy variable (Levfine) indicating whether or not fines had been levied was created and a categorical variable indicating the number of staff dedicated to monitoring and enforcement were included.

4. Results

Results are first reported illustrating the estimated influence of state level environmental policy on the total size of the livestock industry within each state (Table 3). Due to the absence of some of the state data, the data set actually analyzed from 1972 to 1994 in the regression. Providing a variety of justifications (e.g., environmental risk, political expediency, regulatory efficiency), federal and state level environmental policies directed toward the livestock industry have consistently targeted larger operations. Therefore, environmental policy might be expected to influence larger operations more than smaller operations. Thus, the estimated influence of policy on the total size of the livestock industry found in small (<300 AU), medium (300-1000 AU) and large (>1000 AU) operations in the state is reported and compared to the total results (Table 3). All reported relationships are statistically significant by traditional standards. The R-squared measures are particularly strong for panel data, though substantially weaker in explaining the variation in large operation decisions.

Interesting information is found within and among the highlighted treatments. Consistent with traditional predictions, average annual precipitation (Precipt) and land value (Landval) relate negatively to the state size of the livestock industry across

treatments. Potentially contrary to expectations, chicken density (Cexist) and agricultural zoning (Zoning) also demonstrate negative correlation across treatments. The former result can be explained by the fact that chicken production is concentrated (Martin and Zering, Watt and Kennett) in states where human population density is quite high and the potential for livestock industries with large land requirements is lower. The latter result may follow a similar argument. States with less total area (e.g., New England) find agriculture at particular risk to urbanization, impose agricultural zoning regulations, and preserve a relatively small livestock industry within their borders.

Table 3. The influence of environmental policy on livestock industry size

Variable	Total		Small Farm		Medium Farm		Large Farm	
	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
C	103.244	1.9	-125.141	-7.1*	360.749	15.3*	249.485	11.1*
Unemp	19.907	7.2*	35.731	22.6*	-8.436	-8.1*	-2.222	-3.8*
Protax	-0.636	-0.3	6.289	7.9*	4.557	6.8*	-3.038	-6.1*
Precipt	-97.052	-8.9*	-22.150	-5.5*	-70.766	-12.2*	-44.224	-9.8*
Landval	-0.100	-5.4*	-0.151	-15.1*	-0.029	-4.7*	-0.031	-6.3*
Bexist	23.051	38.7*	15.023	55.8*	6.777	21.7*	-1.799	-9.3*
Cexist	-0.451	-9.2*	-0.587	-22.4*	-0.135	-8.3*	-0.055	-5.2*
Dexist	25.246	12.8*	55.204	58.9*	-17.445	-16.2*	-6.626	-21.7*
Hexist	4.420	13.4*	9.552	50.2*	-0.562	-3.9*	0.094	0.7
Bratio	1.597	8.1*	-0.770	-12.9*	0.218	5.4*	0.995	19.3*
Hratio	-3.747	-4.7*	1.539	4.7*	-1.178	-4.2*	-2.676	-15.5*
Bslaught	0.742	6.2*	0.278	13.4*	0.206	6.1*	0.282	5.9*
Hslaught	0.075	9.2*	-0.003	-1.1	0.039	8.9*	-0.018	-4.8*
Regula	61.690	18.2*	38.536	27.2*	18.741	17.7*	15.338	13.8*
Staff	-6.423	-0.6	-19.503	-11.5*	-4.980	-1.7	26.400	6.7*
Levfine	-135.394	-3.5*	-246.656	-15.9*	-0.458	-0.08	106.057	9.8*
Corp	689.306	11.9*	270.399	25.6*	57.714	3.6*	-165.845	-5.3*
Zoning	-83.899	-2.1*	-242.367	-10.4*	-159.157	-12.2*	-120.763	-14.4*
F-Stat	374.65*		1,192.49*		400.45*		105.65*	
R^2	0.875704		0.957311		0.882776		0.665183	
Adj R^2	0.873367		0.956508		0.880571		0.658887	

Note: * denotes significance at the 5% level.

Consistent with expectations, the state unemployment rate (Unemp) and the dairy cow density (Dexist) are negatively correlated with the size of the state's livestock

industry in large and medium farms, but positively related to the size of the industry in small farms and the overall size of the industry. The beef slaughter capacity (Bslaught), a potential indicator of relative transportation costs for producers, is positively correlated with the size of the livestock industry across treatments. Supporting our justification for findings on chicken density through the corollary argument, the beef cattle density (Bexist) is negatively related to the size of the livestock industry found on large farms and positively correlated with the size found on small and medium farms and the overall size of the state's livestock industry.

The hog-corn price ratio (Hratio) is positively related to the size of the state's livestock industry found on small farms and negatively related to the overall size of the industry and the size of the industry found on medium and large farms. The state level hog density (Hexist) is insignificant in predicting the size of the livestock industry found on large operations. It is negatively correlated with the size of the industry found on medium sized operations and positively related to the size of the livestock industry found on small operations and the overall size of the state's livestock industry. The hog slaughter capacity (Hslaughter) is an insignificant predictor of the size of the livestock industry found on small farms, positively correlated with that found on medium farms and negatively correlated with the size of the industry found on large farms and the overall size of the livestock industry. To the extent that large hog states (Iowa and Illinois) are not particularly important in other livestock species (beef cattle specifically) and recognizing the large proportion of contracted supplies from smaller operations, these results can be understood. (Table 4)

Table 4. Regulatory stringency of leading livestock states, by species

Rank	Beef	Chicken	Dairy	Hog
1	Texas (16)	Ohio (14)	Wisconsin (12)	Iowa (18)
2	Nebraska (17)	California (11)	California (11)	North Carolina (16)
3	Kansas (15)	Georgia (14)	New York (4)	Minnesota (12)
4	Oklahoma (19)	Indiana (11)	Pennsylvania (12)	Illinois (18)
5	California (11)	Pennsylvania (12)	Minnesota (12)	Indiana (11)

Note: Parentheses indicate the relative regulatory stringency. Least stringent = 0 and most stringent = 19.Animal Confinement Policy National Task Force, 1998.

The written stringency of regulations (Regula) predicts industry size positively across treatments. The effect is clear, but the direction of causality is unclear. According to economic theory, external productive or consumptive effects of individual or collective behavior may provide adequate justification for government policy (Baumol and Oates); industry should drive policy in the first instance. In support of this hypothesis as applied to environmental policy and the livestock industry by Martin and Norris, we show that all leading livestock producing states, where the largest potential for external productive effects of livestock production on air and water quality are likely to be found, demonstrate a relatively high regulatory stringency ranking as well.

However, alternative explanations can be raised. After regulations are imposed, we would expect firms to take the expected cost of policy compliance into account in view of other factors in making their location and stocking decisions. Written stringency and enforcement are distinct issues; the written stringency of regulations, or the rules of the game, may not affect the expected returns to investment, while enforcement activity, the probability of getting caught breaking the rules, most definitely does. Traditional attractive location factors may outweigh the mitigating influence of stringent policies (Mo and Abdalla, Metcalfe). Moreover, stringent, well-crafted regulations may guide the industry to meet social objectives without increasing production costs. Any of these three

possible post-regulation situations would generate muted impacts on the observed stocking and location decisions of livestock operations driven by the state level environmental policy environment.

Even though regulation appears more likely driven by industry, some evidence in support of the contention that regulation seems to act as a catalyst for structural change in the industry can be inferred from our results. In our estimates, the number of staff dedicated to monitoring and enforcement activities (Staff) and evidence of actual enforcement of the regulations (Levfine) had distinct influences depending upon the size of the livestock industry found on different sized operations within the state. The states with large numbers of livestock found on large operations also have more dedicated staff, enforcement, and more stringent regulations, following the industry drives policy hypothesis. However, the leading livestock states overall show no correlation with dedicated staff and negative correlation with enforcement. Neither dedicated staff nor fines levied correlate with the number of animals found on medium sized farms. The number of livestock found on small farms is negatively correlated with both the number of dedicated staff and the enforcement efforts. These results may tell us that the presence large operations, not large livestock industries, imply greater enforcement efforts. Contrary to conventional wisdom, weaker environmental regulatory enforcement efforts seem to imply more small-scale livestock operations, a larger overall size of the livestock industry, and fewer large-scale livestock operations. Potentially, this result illustrates the increasing prevalence of small contracted producers in the livestock industry in order to avoid the increasingly popular anti-corporate or large farm legislation.

In addition, the dummy variable indicating the presence of legislation restricting corporate ownership of livestock operations (Corp) shows a negative relationship with the size of the livestock industry found on large operations and a positive relationship with the small, medium and overall estimations as expected (e.g., Krause; Matthey and Royer). Following earlier logic, the property tax rate (Protax) is negatively correlated with the overall size of the livestock industry and the size of the industry found on large operations. It is positively correlated with the size of the industry found on small and medium operations.

5. Implications and conclusions

Recent industry trends toward greater industrialization, concentration, and vertical coordination of the U.S. livestock industry may have environmental and social implications (Martin and Zering). National, state and local environmental policy may seek to address these effects. Unfortunately, little information connecting industry performance with policy is in evidence. Policy effectiveness (changes in water quality measures) and enforcement (number and date of fines or operation closures) are not readily available across states. Without effectiveness and enforcement information it is difficult to infer whether a lack of correlation between environmental policy and stocking/location decisions are due to highly efficient policies (those which reach social water quality objectives without increasing livestock production costs) or completely ineffectual policies (no enforcement).

Generally speaking, our results indicate that all of the traditional factors considered are important to farm level location and inventory decision making. Our

results appear to imply that, although environmental policy factors may increase production costs differentially across state lines and operation sizes, either sunk costs in infrastructure and marketing channel development or other advantages the livestock and poultry industries do not appear to have been outweighed by increased regulatory compliance costs in those states. While traditional factors are important, their relative importance appears to vary by size of operation and livestock species. Although it may be that the regulatory environment is driven by the overall size and species composition of the livestock industry, stocking rates appear to be affected by policies targeting large operations, potentially due to high fixed costs of location or the increased prevalence of contracting smaller operations to avoid regulatory compliance costs and as a risk mitigation strategy for the integrator.

We have attempted to relate state level environmental policies to stocking and location decisions of the livestock industry across species and operation size for the entire United States. A number of interesting results have resulted from this effort. In order to improve the information set in this realm we suggest future analyses attempt to incorporate entry and exit information (like manufacturing sector studies have done), include more comprehensive enforcement and effectiveness information over time, and explicit consideration of the potential endogeneity of environmental policy and the size of the livestock industry.

6. References

Bartic, T. J. "The Effects of Environmental Regulation on Business Location in U.S." *Growth and Change*, 19(Summer 1988): 3, 22-44.

Bartic, T. J. "Business Location Decisions in the United States: Estimates of the Effects of Unionization, Taxes, and Other Characteristics of States," *Journal of Business and Econmics Statistics*, 3(1985): 1. 14-22.

Baumol W. J., and W.E. Oates. “The Theory of Environmental Policy.” Cambridge University Press. 1988.

Beghin, John., and M. Metcalfe. “Environmental Regulation and Competitiveness in the Hog Industry: an International Perspective”, working paper, Department of Economics, Iowa State University. 1998.

Biorn Erik., R. Golombek., and R. Arvid. “Environmental Regulations and Plant Exit: A Logit Analysis Based on Establishment Panal Data.” *Environmental and Resource Economics*, 11(1998): 35-59.

Edelman, M., H. M. Harris, A. Seidl, and M. L. Warner. “1998 National Survey of State Animal Confinement Policies.” Animal Confinement Policy Task Force. 1999. Data may be accessed at http://cherokee.agecon.clemson.edu/confine.htm.

Fleming, R.A., B.A. Babcock., and E. Wang. "Resource or Waste? The Economics of Swine Manure Storage and Management." *Review of Agricultural Economics*. 20(1998):1 96-113.

Gomez, I A., H.A., Love., and D. M. Burton. “Analysis of the Effects of Environmental Regulation on the Pulp and Paper Industry Structure.” American Agricultural Economics Association Annual Meeting. 1998.

Gray, W. B. “Manufacturing Plant Location: Does State Pollution Regulation Matter?” Working Paper 5880, NBER Working Paper Series, National Bureau of Economic Research, 1997.

Greene, W. “Models for Panel Data.” In *Econometric Analysis*, 4th ed, pp. 557-689. Prentice Hall, 2000.

Hemmer, R. “Some Impacts of Arizona Department of Environmental Quality (ADEQ) Enforcement in the Dairy Industry in the Maricopa County, Arizona.” AAEA Session OS-7F. 1998.

Henderson, J. V. “Effects of Air Quality Regulation.” *The American Economic Review*, 86(September 1996):4 789-813.

Hsiao, C. Analysis of Panel data. Econometric Society Monographs, No.11, 1999.

Hubbell. B.H., “Entropy Based Measurement of Geographic Concentration in U.S Hog Production.” FS-97-02, Dept. of Agricultural and Applied Economics, University of Georgia, 1997.

Hurley, S. P., and J. B. Kliebenstein. “The Potential for Marketing Pork Products with Embedded Environmental Attributes: Results from an Experimental Study.” Selected Paper Presented at the American Agricultural Association Meetings. 1999.

Innes, R. "Regulating Livestock Waste: An Economic Prospective." *Choices*, Second Quarter (1999): 14-19.

Judge, G. G., W. E. Griffiths, R. C. Hill. H. Lutkepohl., and T.-c. Lee. “Inference in Models That Combine Time Series and Cross-sectional Data.” In *the Theory and Practice of Econometrics*, pp. 515-554. New York: John Wiley and Sons, Inc., 1985.

Kmenta, J. “pooling of Cross-sectional and Time-Series Data.” In *Elements of Econometrics*, 2nd ed, pp. 616-634. Macmillan Publishing Company, 1986.

Kuch, P. J., and I. S. Lovell. " Rethinking Regulation of Animal Agriculture." *Choices* Second Quarter (1999): 9-13.

Lawrence, J. D. “What's Ahead for the U.S. Pork Industry:” Presented at National Pork Producers Competitiveness Seminars, Various cities. 1997.

Levinson A. “Environmental Regulations and Manufacturers’ Location Choices: Evidence from the Census of Manufactures.” *Journal of Public Economics*, 62(1996): 5-29

Martin, L L., and P. E. Norris, "Environmental Quality, Environmental Regulation and the Structure of Animal Agriculture.” *Feedstuffs*, 70(May 1998): 18. (Missing Pages)

Martin, L. L., and K. D. Zering. "Relationship Between Industrialized Agriculture and Environmental Consequences: The Case of Vertical coordination in Broilers and Hogs.” *Journal of Agricultural and Applied Economics*, 29(1997): 1 45-56.

Matthey. H., and J. S. Royer. “Testing the Impact of Corporate Farming Laws on Hog Industry Growth: A Partial Adjustment Approach.” Selected Paper, American Agricultural Economics Association Meetings, Nashvile, TE, August, 1999.

McConnell, V. D., and R. M. Schwab. “ The Impact of Environmental Regulation on Industry Location Decisions: The Motor Vehicle Industry.” *Land Economics*, 66(February 1990):1 67-81.

Metcalfe, M. “Environmental Regulation and the Effect on Hog Production in U.S. Domestic and International Markets.” Working Paper. 1999.

Metcalfe, M. “Location of Production and Endogenous Water Quality Regulation: A Look at the US Hog Industry.” Working Paper. 1999.

Metcalfe, M. “State Legislation Regulating Animal Waste Management.” 1999. Working Paper.

Metcalfe, M., and J. C. Beghin. “Piecemeal Reform of Trade and Environmental Policy When Consumption Also Pollutes.” Working Paper 99-WP 209.Center for Agricultural and Rural Development, Iowa State University. 1999.

Mo, Yin., and C. Abdalla. “Analysis of Swine Industry Expansion in the U.S: The Effect of Environmental Regulation.” Discussion paper, Staff Paper 316. Agricultural Economics and Rural Sociology, College of Agricultural Sciences, The Pennsylvania State University. 1998.

National Pork Producers Council. “A Review of State Environmental regulatory Enforcement Actions.” 1996.

National Pork Producers Council. “Testimony of Jim Moseley on Behalf of NPPC Concerning Animal Waste Management.” 1998.

National Pork Producers Council. “Most Commonly Asked Question about Pork Production and Environment.” 1999.

National Pork Producers Council. “Pork Industry Environmental Impact Facts.” 1999.

National Pork Producers Council. “An Introduction to the Comprehensive Regulatory Framework for Pork Production.” 1997.

Norris, P. E., and A. P. Thurow. “Environmental Policy and Technology Adoption in Animal Agriculture.” AEC Staff Paper 97-28, Department of Agricultural Economics, Michigan State University. 1997.

Pritchet, J. G., and D. J. Liu. “Estimating Backward Integration in a Primary Input Market: The Case of U.S. Hog Industry.” Department of Applied Economics, University of Minnesota. 1998.

Rhodes, V, J. “The Industrialization of Hog Production.” *Review of Agricultural Economics*.” 17(1995): 107-118.

Schnitkey, G., and M. Miranda. "The Impact of Pollution Controls on Livestock-Crop Production." *Journal of Agriculture and Resource Economics*. 18(1993): 25-36.

Schrader, L. F. “Coordination in the United States Hog/Pork Industry.” Staff Paper #98-19. Department of Agricultural Economics, Purdue University. 1998.

Thurow, A. P., and J. Holt. "Induced Policy Innovation: Environmental Compliance Requirements fir Dairies in Texas and Florida". *Journal of Agricultural and Applied Economics*, 29(1997):1, 17-36.

U.S. Environmental Protection Agency, Office of Water. “Guide Manual on NPDES Regulations For Concentrated Animal Feeding Operations.” EPA 833-B-95-001, Washington DC. 1995.

U.S. Department of Agriculture and U.S. Environmental Protection Agency. “Unified National Strategy for Animal Feeding Operations.” 1998.