자원환경경제연구 제 15 권 제 1 호
Environmental and Resource Economics Review
Volume 15, Number 1, February 2006 : pp. 1~25

The Impacts of Environmental Policy on Livestock Stocking and Location by Industry Size

Dooho Park*

<Contents>

Ⅰ. Introduction

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

* Korea Water Resources Corporation, Korea Institute of Water and Environment, Senior Researcher.

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, are also subject to federal regulation. Currently, 43 states have been granted enforcement authority of NPDES permits by the EPA (USEPA, 1999).

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.*, 1999). Especially, environmental policies applied to livestock generally are directed toward larger, incorporated, or vertically integrated operations (Martin and Zering, 1997; Hubbell, 1997; Metcalfe, 2000). These policies tend to address ground and surface water quality concerns and increasingly, air quality issues.

Livestock industry structure also has undergone recent measurable change. The average size of livestock operations has changed substantially. Since 1970, a consistent downward trend in the number of livestock found on farms of size smaller than 300 Animal Units (AU) is observed. This trend was most pronounced in the mid 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 early 1970s, but remained stable over the 30 years period. The number of livestock found on operations greater than 1000 AU in size climbed steadily, except the early 1980s, and accelerated from the mid 1980s through the 1990s (<Table 1>).

Technological innovation and low transportation costs have increased location alternatives and firm/industry structure decisions by weakening

<Table 1> Annual Percent Change in Number of Animal Units Found on Livestock Operations, by Operation Size (Unit : %)

Year	Small Operation	Medium Operation	Large Operation
1970	2.07	5.43	3.35
1972	2.16	4.90	3.30
1974	2.26	4.46	3.10
1976	0.13	1.19	5.96
1978	0.13	1.22	5.33
1980	0.85	1.76	0.13
1982	0.86	1.70	0.13
1984	3.22	1.53	2.99
1986	3.44	1.58	2.82
1988	2.00	1.77	4.15
1990	2.08	1.71	3.83
1992	2.17	1.65	3.56
1994	2.36	0.84	6.65
1996	2.48	0.85	5.87

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

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 171%, 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 (USDA, NASS, 1999). In 1972, 17% of all broilers are 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, 1995).

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. Economic theory tells us that productive and consumptive externalities provide the impetus for public policy; policy is reactive. However, experience tells us that policy can be put in place in anticipation of social costs; policy can be proactive. We also know that once policies are in place, firms will incorporate the costs of compliance (adjusted for the probability and cost of noncompliance) into their production function; industry reacts to positive and negative financial incentives. The literature on this subject commonly poses this classical “chicken and egg” problem; the stringency of environmental regulations either (a) is driven by or (b) is the catalyst for change in livestock industry stocking and location decisions (Mo and Abdalla, 1998; Martin and Norris, 1998). Alternatively, the willingness and ability to enforce these regulations, rather than their written stringency, may affect location and stocking decisions. State and local policy, may affect or be driven by operation size, legal structure or livestock species or may be reflect a cumulative effect of all livestock operations or stock of animals combined. 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 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 mirror the imposition of new environmental policies. The stringency of environmental regulation coupled with the greatest willingness to enforce is expected to most strongly guide the evolution of the livestock industry when location factors are most open.

The main objectives of this analysis are following;

First, examine whether state level environmental policies influence different size of operation in a distinct manner.

Second, examine whether the willingness to enforce differ from written stringency of regulation.

Ⅱ. Previous Researches

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.

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 and Abdalla, 1998). Industries studied include: plants of Fortune 500 manufacturers (Bartik, 1988); automotive plant location (McConnell and Schwab, 1990); all industries falling under ozone regulations (Henderson, 1996); and the pulp and paper industry (Gomez *et al.*, 1998). Analytical techniques include: microeconomic conditional logit specifications (McFadden, 1974; Bartik, 1988; McConnell and Schwab, 1990; Levinson, 1996; Gray, 1997); a microeconomic fixed effects model of panel data (Henderson, 1996); and a macroeconomic stationary Markov chain model (Gomez *et al.*, 1998).

Most results suggest that geographic environmental policy variation has little effect on plant location (Bartik, 1988; McConnell and Schwab, 1990; Levinson, 1996), 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, 1996; Gray, 1997) and one study (Gomez *et al.*, 1998) shows that the policy environment influences plant capacity decisions.

2. Environmental Policy and the Livestock Industry

Unlike analyses of the manufacturing sector, most research on livestock was industry (species) specific. Taken as a body of research, the results were inconclusive. Thurow and Holt (1997) find that the timing and sequencing of policy signals influence compliance behavior and options for Texan and Floridian dairies; policy influences firm decision-making. Mo and Abdalla (1998) 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 (1998) summarized 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 (1999) extended Mo and Abdalla (1998) 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' (1998) observation. Metcalfe (1999) failed 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 are significant predictors of hog production and location decisions (Metcalfe, 1999).

Ⅲ. Data and Analytical Approach

1. Data Compilation and Manipulation

The data required for this analysis include animal inventory and number of operations by size, livestock species, and state over time. To fulfill these needs, agricultural census data (USDA, NASS, 1999) are compiled and manipulated from 48 states (due to a large amount of missing data for Alaska and Hawaii) for dairy, swine, beef cattle and broiler industries over almost three decades (1969 to 1997). The environmental regulation factors are based upon the "1998 National Survey of Animal Confinement Policies" database containing information from 48 states (Louisiana and West Virginia chose not to respond, Edelman *et al.*, 1999) NASS "Historical Data" provided the source for the rest of the variables (USDA, NASS, 1999). Data sources, units and variables are summarized in (<Table 2>).

Annual state total animal inventory was calculated using animal unit equivalents. EPA standards are used and dry systems are 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. These data are manipulated to create variables indicating the number of animal units found on operations in three size categories in each state over time. These size categories reflect the standards set forward by the CWA. Values for non-census years are assigned based upon a linear extrapolation of intra-census trends. As a representation of relative profitability of the industry across location and time a state level beef and hog corn price ratio was included. Available labor may attract more animal operations and livestock to the state. State unemployment rates are compiled and included, as a relative loose labor market might be expected to encourage industry expansion. As an indicator of industry transportation costs, combined annual beef and hog slaughtering capacity by state are included. All of these variables are expected to correlate positively with total state livestock industry.

<Table 2> List of Variables in the Analysis

Variable	Units	Abbreviation	Sources
Inventory – Beef	Head	Binven	USDA, NASS
		Cinven	
Chicken			
Dairy		Dinven	
Hog		Hinven	
Animal Units	AU	AnitotG1-G3	USDA, NASS
Animal Corn Price Ratio			
Beef		Bratio(B/C)	USDA, NASS
Hog		Hratio(H/C)	
Slaughtering Capacity (Beef + Hog)	Lbs	Slaught	USDA, NASS
Land Value	$/acre	Landval	USDA, NASS
Unemployment Rate		Unemp	Census Bureau
Population Density	People/Private land (1,000 acres)	Popden	USDA, NASS Census Bureau
Annual Average Precipitation	Inches	Precipt	USDA, NASS
Property Tax	$/acre	Protax	USDA, NASS
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 Agricultural Zoning	(0,1)	Zoning	Task Force Survey

Notes : G1, G2 and G3 are small (<300AU), medium (300-1000AU) and large (>1000AU) operations, respectively.

Since greater livestock-human interaction is likely to result in more conflict and greater perceived negative externalities, a variable describing the likelihood of this interaction was constructed. Both people and livestock spend most of their time on private land, the likelihood of their interaction increases as their populations increase and as developable land decreases. Population data and the amount of private land by state over five census periods are compiled (1960, 1970, 1980, 1990, and 2000) and a measure of population density on developable land by state and over time was calculated. Potentially, higher population density in the state will correlate with less animal inventory growth in that state.

Land prices are an indicator of an important production cost in the livestock industry. Land values are an indicator of population growth pressure, land use policies, resident wealth and income, and current and future land use. State property tax also should be considered as an indicator of the business climate of the state. The states' average annual precipitation was taken into account to represent the state level climatic variation and environmental vulnerability. All three variables are expected to correlate negatively with the state livestock inventory.

A proxy variable (Regula) was constructed to represent the general stringency of state regulations using recent survey information (Edelman *et al.*, 1999). The index was constructed as an un-weighted sum of affirmative responses to twenty-nine regulatory stringency-related survey questions. Nineteen affirmative responses was the maximum observed and zero affirmative responses provided the lower bound on the regulatory stringency index.

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 are included.

2. Methodological Approach

The most popular approach for dealing with panel data is the error components model, which is specified as :

$$Y_{it} = X_{it}\beta + Z_i\gamma + \alpha_i + \eta_{it}, \ (i = 1, \cdots, N; t = 1, \cdots, T) \quad (1)$$

where the vectors X_{it} and Z_i are time-varying and time-invariant variables respectively. The α_i represents the unobservable effect believed to exist across units, while the η_{it} is the usual stochastic error term. The observations are across, T time periods and N units. In this research, the coefficients on the time invariant Z_i are of central importance, which creates several estimation challenges.

Depending on model specification, either a fixed or random effects model can be applied to derive estimates of the α_i. Hsiao (1999) suggests that if an experiment involves individuals who are considered a random sample from a larger population, random effects are more appropriate. However, if the situation is one of analyzing just a few individuals and the sole interest lies in the just these individuals, then individual effects would more appropriately be fixed, not random. Mundlak (1978) suggests that α_i should generally be considered random effect. Other factors can be a determinant of this estimation decision as well. For example, the estimates of β_i become similar between random and fixed effects when there exists a long time series in the panel.

For this research, a fixed effects model leads to a complication. The coefficients for time-varying variables are estimated using OLS after the WITHIN transformation, so that $\hat{B}_W = (X'Q_V X)^{-1} X'Q_V Y$. The $Q_V = I_N \otimes i(i'i)^{-1} i'$ is a projection operator that takes deviations from the unit mean of each variable in the X or Y matrices.

Thus, $(Q_V X)_{it} = (X_{it} - \overline{X}_i)$ and $(Q_V Z)_i = (Z_i - \overline{Z}_i)$; as Hausman and Taylor (1981) note, the Q_V transformation of Z_i leaves a vector of zeros because $Z_i = \overline{Z}_i$. Thus, all time-invariant variables are eliminated by the WITHIN transformation, and γ, the environmental variables of interest here, cannot be estimated. As such, alternatives are needed. A random effects model can be used, or, building on Hausman and Taylor (1981), a two-stage method by Alvarez and Gonzelez (1999) can be used for estimating γ_i when a fixed effects model is preferred. The remainder of this section addresses that choice and the techniques used when estimating a random or fixed effects model.

The determination of whether to use a random or fixed effects model is based the variances of α_i and η_{it}, and a derived value, Θ. Let

$$\sigma_\eta^2 = \underset{n\to\infty}{plim} \frac{1}{N(T-1)} \eta_{it}' Q_v \eta_{it} \quad (2)$$

$$s^2 = (1/N)(Y_{i\cdot} - X_{i\cdot}\hat{\beta}_W - Z_i\hat{\gamma}_W)'(Y_{i\cdot} - X_{i\cdot}\hat{\beta}_W - Z_i\hat{\gamma}_W) \quad (3)$$

$$\sigma_\alpha^2 = s^2 - (1/T)\sigma_\eta^2 \quad (4)$$

$$\Theta = [\sigma_\eta^2 / (\sigma_\eta^2 + T\sigma_\alpha^2)]^{1/2} \quad (5)$$

where σ_η^2 is the variance of the time varying error term estimated from the residuals of the fixed effects regression on just the X_{it}

(because the Z_i are swept out from this estimation). s^2 is the overall variance of the composed error calculated from the BETWEEN regression, and is used to create the σ_α^2 in the third equation. $\hat{\beta}_W$ and $\hat{\gamma}_W$ are the WITHIN estimates for the time varying and time invariant coefficients respectively (the latter to be discussed below). $Y_{i\cdot} = (1/T)\sum Y_{it}$ and the $X_{i\cdot} = (1/T)\sum X_{it}$ are the unit means, averaged across all time periods for the dependent and independent variables. These variances are used in calculate a weighting variable, Θ, which helps determine whether to use the fixed or random effects model and becomes the weight for the GLS or random effects model (Greene, 2000; Hausman and Taylor, 1981).[1] For a given observation, Θ is used to create the weighting matrix $\Omega^{-1/2}$ used in GLS transformation.

$$\Omega^{-1/2} = \Theta P_v + Q_v = I_{TN} - (1-\Theta)P_v \qquad (6)$$
$$\Omega^{-1/2} = \Omega^{-1/2}X_{it}\beta + \Omega^{-1/2}Z_i\gamma + \Omega^{-1/2}\alpha_i + \Omega^{-1/2}\eta_{it} \ or$$
$$Y_{it} - (1-\Theta)Y_{i\cdot} = [X_{it} - (1-\Theta)X_{it\cdot}]\beta + \Theta Z_i\gamma + \Theta\alpha_i + [\eta_{it} - (1-\Theta)\eta_{i\cdot}]$$

** P_v makes vector of group mean, so $P_vY_{it} = (1/T)\sum Y_{it} = Y_{i\cdot}$*

The above equations show that the random effects estimator differences the data after a fashion, depending on the value of Θ. At one extreme, if σ_α^2 are zero, then Θ goes to 1, and GLS becomes ordinary least squares, as the Y_i. and X_i. terms drop out. If Θ

1) My presentation is based on Hausman and Taylor's (1981) definition of Θ, which is equivalent to Greene's λ. Greene also used a Θ, where $\lambda=1-\Theta$ in his terminology. This is just another indication that industry standards have not totally reached the econometrics literature.

equals zero, then σ_{η}^{2} is zero, and all variation across units would be due to the α_i; the equation (6) above thus reduces to the dummy variable, or fixed effects estimator. It is also clear from the equation above that the Z_i variables

<Table 3> Estimated θ for Each Group

Total	Small Farm	Medium Farm	Large Farm
0.1532	0.0907	0.0308	0.2311

are affected, as they enter OLS in their original form when θ is 1 and drop out of the equation when $\theta=0$.

The final issue related to the methods here is when the $\theta=0$. Therefore, two step estimation has been conducted, which was developed by Alvarez and Gonzalez(1999). The first step is to estimate a fixed effect panel data model with all time-varying variables. The model is following;

$$Y_{it} = \alpha + X_{it}\beta + \eta_{it} - v_i \ (\alpha_i = \alpha - v_i) \qquad (7)$$

where α_i is the fixed effects of each cross section units.

In the second step, $\hat{\alpha}_i$ was adjusted by regressing it against the set of cross sectional characteristics which are time-invariant variables expressed as Z_i. The equation is a cross sectional OLS estimation of $\alpha_i = Z_i\gamma + u_i$. The α_i is the residual from the WITHIN estimation, and this results become the dependent variable in the second stage. The expression for $\hat{\alpha}_i$ shows that the within residuals.

$$\hat{\alpha}_i = Y_{i\cdot} - X_i{}'\cdot\hat{\beta}_w = [P_V - X_{i\cdot}(X_{it}{}'Q_V X_{it})^{-1} X_{it}{}'Q_V]$$
$$= \alpha + Z_i{}'\gamma + v_i + [P_V - X_{i\cdot}(X_{it}{}'Q_V X_{it})^{-1} X_{i\cdot}{}'Q_V]\varepsilon_{it\cdot} \quad (8)$$

The values of θ calculated for each equation in this paper, corresponding to different sizes of livestock operations, are given in <Table 3> above. For Large Farm categories we cannot infer that σ_η^2 equals zero. As a result, the appropriate alternative estimation method is generalized least squares, which can be transformed by "θ". On the other hand, the θ_S of Small and Medium Farm categories are nearly zero, which means σ_η^2 might be zero and I can use the fixed effect setting.

Ⅳ. Results

Since many environmental policies, including the CWA,[2] explicitly differentiate larger from smaller operations for mandatory compliance, it is appropriate for our analysis to reflect this differentiation. Instead of total industry impact, size categories (i.e. livestock inventories found on small, medium and large operations) become the dependent variables in this

2) Federal regulations define a Concentrated Animal Feeding Operation (CAFO) as an animal feeding operation that: confines more than 1,000 animal units (AU); or confines between 301 to 1,000 AU and discharges pollutants into waters of the United States through a man-made ditch, flushing system, or similar man-made device; or directly into waters of the United States that originate outside of and pass over, across, or through the facility or otherwise come into direct contact with the animals confined in the operation (USEPA, 1998).

analysis.

Each of the three estimated relationships is statistically robust, describing 75% of the variation found in the livestock inventory found on small farms, 78% of that found in medium operations, and 61% of that variation in large farms (<Table 4>). Eleven of the thirteen predictive variables were statistically significant in the small farm estimations, and

<Table 4> Random Effects Model for Size Analysis

Variables	Small Operation		Medium Operation		Large Operation	
	Coeffs	*t*-stats	Coeffs	*t*-stats	Coeffs	*t*-stats
C	1110307	4.98*	912809	7.62*	631159	4.24*
Unemp	7780	0.61	14032	2.06*	6450	0.68
Protax	13918	2.07*	29412	8.23*	27473	5.52*
Precipt	12093	4.99*	6778	5.25*	9953	5.55*
Landval	102	2.26*	67	2.80*	62	1.84**
Popden	316	2.50*	526	7.80*	404	4.31*
Bratio	3244	7.92*	120	0.55	1621	5.32*
Hratio	6620	2.19*	279	0.17	2308	1.02
Slaught	603	7.02*	392	8.56*	470	7.38*
Regula	424	1.69**	37	0.28	45	0.24
Staff	10568	1.25	15057	3.35*	27992	4.53*
Levfine	381654	4.85*	453201	10.81*	475853	8.21*
Corp	2334464	18.39*	1218886	18.03*	550214	5.88*
Zoning	232986	2.38*	62961	1.21	19499	0.27
R^2	0.7531		0.7748		0.6057	
Adj R^2	0.7508		0.7727		0.6020	

Note : * and ** denote significance at 5% and 10% level, respectively.

9 were significant in the medium and large operation models.

For small farm inventories, only the number of staff dedicated to regulatory compliance and the state unemployment rate were statistically uncorrelated with the size of the livestock inventory. In contrast, on medium sized operations, both of these variables were significant predictors of livestock inventories, but the hog and beef to corn price ratios, the regulatory stringency index and the presence of agricultural zoning were not found to be significant. On large farms, the hog to corn price ratio, agricultural zoning and regulatory stringency remained insignificant paralleling findings for medium sized operations. Like small operations, the beef-corn price ratio became significantly predictive and unemployment became insignificant in estimations involving large operations (<Table 4>).

More often and more importantly, where predictive variables were significant, the magnitude and direction of impact varied substantially across farm size categories, as hypothesized. Interesting information is found within the highlighted treatments. The effect of the state unemployment rate (Unemp) was insignificant in small and large farm estimates and significantly positive for the medium farm estimate. Several explanations are possible. Most obviously, families, who do not need extra labor, usually operate small farms. Many large concentrated operations, which have the skilled labor already, also may not need to absorb excess labor in the state. The high technology based new large farms seem to be less connected to excessive (often low skill) state labor (Delind, 1998).

As a representation of the profitability of livestock operations, beef/corn and hog/corn price ratios (Bratio and Hratio) have distinct impacts on the state livestock inventory. The beef/corn price ratio was negative for small operations, insignificant for medium and positive for large operations. This implies that large sized farms are most abundant where it is most profitable to operate. It may be that more beef inventory is found on large operations relative to other livestock species, thus making these categories more sensitive to the beef/corn price ratio. Alternatively, small farms may depend less on purchased inputs, or on the livestock portion of their production portfolio. Another possible reason may be due to less structural change within the beef industry (<Table 1, 2>).

On the other hand, the hog/corn price ratio was positive for small farm estimates, but not significant for the medium and large farm estimations. This result probably reflects the specialization of the hog industry on larger operations. Farrow and nursery operations have a far lower portion of their production costs dictated by feed prices than finish operations. As a result, although corn prices may create a significant driver for the location of hog finishing operations, other input cost advantages tend to drive the location of farrow and nursery operations. Since smaller operations remain farrow-to-finish, they are more likely to be concentrated where corn prices are lower than are other portions of the industry.

Edelman *et al.* (1999) found that hogs are the most controversial species in most states. It potentially creates a relatively restrictive livestock regulatory environment in large hog industry states. As a result, other livestock sub industries (beef, poultry and dairy) may try to avoid states with large hog operations. Therefore, it creates downward pressure on the total state livestock inventory, particularly emanating from large operations. For example, Texas, California and Nebraska have the greatest total livestock inventory found on large operations in the United States, but are minor players in the hog industry.

The total of beef and hog slaughter capacity (Slaught) was significant in estimation of all sizes of operations. This implies that greater slaughter capacity, and presumably, lower transportation costs to slaughter, were found where a high number of livestock are found. This result may be indicative of the traditionally dominant role of transportation costs in the industry, or of the relatively higher fixed costs of establishing a slaughter plant relative to a livestock production operation. Furthermore, vertical coordination of the hog and the poultry industry drives higher inventories and more slaughtering plants in the same places.

Unlike the total industry analysis, stratification by size generated statistically significant results for both land value and property tax, bundled components of input costs. Land value (Landval) was positively correlated with livestock inventories in small operations, but, as expected, is negatively related to the medium and large operation category. Property tax follows the opposite pattern. Several explanations may be posed to address this result. Small operations are more likely to have off farm income as a component of total family income. As a result, location nearer to urban areas, and higher land prices, may become a reasonable choice. On the other hand, it may be that only small operations remain near urban and suburban areas. Higher property taxes diminish the incentive to speculate on small, high priced, properties for alternative development uses. The combination of low land prices and higher property taxes favor larger operations, which are less likely to convert their land out of agricultural uses and are more likely to lease at least a portion of their productive lands. Moreover, population density was negatively related to all size categories, indicative of the pressure to convert land to residential or commercial uses.

Regulatory stringency had no significant impacts on inventory and location decisions on medium and large operations, despite the fact that such regulations often target larger operations. 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 on the inventory and location of the livestock industry. The states with larger numbers of livestock found on medium and large operations have more dedicated staff and more stringent regulations, but less evidence of enforcement, following the industry-drives-policy hypothesis. The results show that fines levied had a significant negative impact across all sizes of the industry, indicating that the state's willingness to enforce regulations, rather than their written stringency, is the cost factor entering into producer decisions.

Contrary to expectations, the presence of legislation restricting corporate ownership (Corp) showed a strong positive relationship across all sizes of the operations. Although corporateness and largeness may be related, it also may be that states with anti corporate legislation tend to have a relatively important traditional agriculture sector (populated by small and middle sized full time farmers) relative to the total economy. Therefore, state anti-corporate laws may encourage more small and medium farms. As indicated earlier, large operations may have found legal loopholes or have been "grandfathered in" to recently impose anti corporate regulations. On a related issue, agricultural zoning regulations were expected to positively influence livestock inventories. Our results indicate that small farms are protected or encouraged by such zoning, but that it had no discernible effect on larger operations. It may be that larger operations are of sufficient size to insulate themselves from the typical challenges facing smaller operations (e.g., threats of nuisance suits, difficulty moving machinery across discontinuous holdings), or that they are not covered by such legislation since they are often defined as commercial or industrial operations beyond a certain size.

Ⅴ. Implications and Conclusions

The economic advantages of scale economies in agriculture, increasing demands for environmental quality and an increasingly urbanized population create policy challenges for individuals, communities and the nation (Martin and Zering, 1997). U.S. livestock industries produce important economic benefits in their host communities. For example, the top ranking 4 states, Texas (beef cattle), Wisconsin (dairy), Iowa (hog) and Georgia (chickens) contributed $4.3 billion, $2.9 billion, $2.8 billion and $2.2 billion in sales revenues to their state's economy, respectively (USDA-NASS, 1999). However, manure, an unavoidable joint product of production, may create environmental and economic costs mitigating the contribution of the industry to society. Regulators, researchers and communities have raised concerns about the potential impacts of manure concentration. Efficient policies are, therefore, justified to bring private and social benefit and cost conditions together toward a maximization of social welfare.

Unfortunately, little information connecting industry performance with policy is in evidence. Policy effectiveness (changes in water quality measures) and enforcement (number, amount 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 inventory/location decisions is due to highly efficient policies (those which reach social water quality objectives without increasing livestock production costs) or completely ineffectual policies (no enforcement).

Dynamic conditions within the livestock industry provide challenges in isolating the real impact of state's environmental regulations. The traditional economic factors are still important to farm level inventory decision making, but their influence varies across operation size. Results appear to imply that, although environmental policy (Regulatory stringency index) 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. However, results point to distinct effects of written stringency and evidence of the willingness to enforce environmental policy. Policy enforcement activity was shown to influence inventory decisions in general and larger operations were found to be more sensitive to willingness to enforce than smaller operations.

In general expectation, the more stringent the regulation, the higher the environmental compliance costs. Therefore, the test hypothesis was that "stringent state level regulation leads to a decline in animal inventories in the state, differentiated by its size of operations."

Panel data estimates tentatively show that the state regulation does have an impact on the livestock industry. Generally, regulations seem to be induced by the structural change of industry; when industry creates externalities, regulators try to address them with policy tools. Written regulatory stringency may not effect behavioral change; rather the state's willingness to enforce regulations seems to have a measurable influence. However, in the presence of rapid structural change of livestock industry, industry location is affected by written regulatory stringency.

An attempt has been made to relate state level environmental policies to livestock inventories by operation size for the entire United States, providing greater depth, breadth and methodological sophistication than previous work in this area. A number of interesting results have resulted from this effort. As always, refinements could be made. In order to improve the information set in this realm, future analyses attempt to incorporate entry and exit information (as manufacturing sector studies have done), compile and include more comprehensive and temporally specific enforcement and effectiveness information, and explicitly consider the potential endogeneity of environmental policy and the size and species of the livestock industry.

◎ *References* ◎

1. Alvarez, M. A. and E. Gonzalez, "Using Cross Section Data to Adjust Technical Efficiency Indexes Estimated with Panel Data," *American Journal of Agricultural Economics*, Vol. 81, 1999, pp. 894 ~ 901.
2. Bartik, T. J., "The Effects of Environmental Regulation on Business Location in U.S.," *Growth and Change*, Vol. 19, 1988, pp. 22 ~ 44.
3. Delind, L. B. Parama, "A Story of Hog Hotels and Local Resistance, In Pigs, Profits, and Rural Communities (Thu and Durrenberger, Eds)," State University of New York

Press, Albany, NY, 1998.

4. Edelman, M., H. M. Harris, A. Seidl and M. L. Warner, "1998 National Survey of State Animal Confinement Policies," Animal Confinement Policy Task Force, Data May be Accessed at http://cherokee.agecon.clemson.edu/confine.htm, 1999.
5. 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.
6. Gray, W. B., "Manufacturing Plant Location: Does State Pollution Regulation Matter?" Working Paper 5880, NBER Working Paper Series, National Bureau of Economic Research, 1997.
7. Greene, W., "Models for Panel Data," *In Econometric Analysis*, 4th ed, Prentice Hall, 2000, pp. 557 ~ 689.
8. Hausman, J. J. and W. E. Taylor, "Panel Data and Unobservable Individual Effect," *Econometrica*, Vol. 49:6, 1981, pp. 1377 ~ 1398.
9. Henderson, J. V., "Effects of Air Quality Regulation," *The American Economic Review*, Vol. 86:4, 1996, pp. 789 ~ 813.
10. Hsiao, C., "Simple Regression with Variable Intercepts," *In Analysis of Panel Data*, Econometric Society Monographs, Vol. 11, 1999, pp. 25 ~ 70.
11. 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.
12. Levinson, A., "Environmental Regulations and Manufacturers' Location Choices: Evidence from the Census of Manufactures," *Journal of Public Economics*, Vol. 62, 1996, pp. 5 ~ 29.
13. Martin, L. L. and P. E. Norris, "Environmental Quality, Environmental Regulation and the Structure of Animal Agriculture," *Feedstuffs*, Vol. 70, 1998.
14. Martin, L. L. and K. D. Zering, "Relationship BetIen Industrialized Agriculture and Environmental Consequences: The Case of Vertical Coordination in Broilers and Hogs,"

Journal of Agricultural and Applied Economics, Vol. 29: 1, 1997, pp. 45 ~ 56.

15. McConnell, V. D. and R. M. Schwab, "The Impact of Environmental Regulation on Industry Location Decisions: The Motor Vehicle Industry," *Land Economics*, Vol. 66:1, 1990, pp. 67 ~ 81.
16. McFadden, D., "Conditional Logit Analysis of Qualitative Choice Behavior," *Frontiers in Econometrics* (Academic Press), 1974, pp. 105 ~ 142.
17. Metcalfe, M., "Location of Production and Endogenous Water Quality Regulation: A Look at the US Hog Industry," Working Paper, 1999.
18. Metcalfe, M., "State Legislation Regulating Animal Manure Management," *Review of Agricultural Economics*, Vol. 22:2, 2000, pp. 519 ~ 532.
19. 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.
20. Mundlak, Y., "On the Pooling of Time Series and Cross Section Data," *Econometrica*, Vol. 46, 1978, pp. 69 ~ 85.
21. Thurow, A. P. and J. Holt, "Induced Policy Innovation: Environmental Compliance Requarements fir Dairies in Texas and Florida," *Journal of Agricultural and Applied Economics*, Vol. 29:1, 1997, pp. 17 ~ 36.
22. USDA, NASS, "1997 Census of Agriculture," U.S. Department of Agriculture, National Agricultural Statistics Service, 1999.
23. ________, "Historical Data," U.S. Department of Agriculture, National Agricultural Statistics Service, 1999.
24. USDA and USEPA, "Unified National Strategy for Animal Feeding Operations," United States Department of Agriculture and the Environmental Protection Agency, 1998.
25. USEPA, "EPA State Compendium: Programs and Regulatory Activities Related to Animal Feeding Operations," 1999.

26. Watts, G. and C. Kennett, “The Broiler Industry,” *In The Poultry Tribune*, Centennial Edition, 1995, pp. 6 ~ 18.

요 약

환경정책이 축산업의 규모와 입지에 미친 파급효과
— 축산농가 규모별 분석 —

박 두 호

본 연구는 미국 주정부의 환경정책과 축산업의 규모 및 입지 선정과의 관계에 대한 분석을 시도하였다. 분석은 업종별이 아닌 소규모, 중규모 그리고 대규모의 세 가지 규모별로 미국의 48개 주의 29년 자료를 이용한 Panel 분석을 이용하였다. 결론을 보면 일반적으로 축산업에 대한 규제는 축산업의 구조변화에 기인한 것으로 판단된다. 산업부문으로부터 외부효과를 정부정책의 틀 안에서 내재화하기 위한 노력인 것이다. 그러나 단순히 제도의 존재 여부는 산업부문의 행위에 결정적인 영향을 주지 못하며 주정부가 규제에 대한 집행의사를 가질 때에만 영향을 줄 수 있었다. 그러나 산업부문의 급격한 구조변화가 있는 경우 주정부의 제도 존재 여부도 영향력이 있는 것으로 판단된다. 특히 축산규모에 따라 그 영향이 달랐으며 대규모 농가가 소규모 농가보다 민감하게 반응하는 것으로 나타났다.

주제어 : 환경정책, 축산업, 패널분석, 규제집행의사

The Impacts of Environmental Policy on Livestock Stocking and Location by Industry Size

Dooho Park

This paper explores the relatatilonship 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, 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 (29 years), which is panel data analysis. Generally, regulations seem to be induced by the structural change of industry; when industry creates externalities, regulators try to address them with policy tools to internalize them. Written regulatory stringency may not effect behavioral change; rather the state's willingness to enforce regulations seems to have a measurable influence. However, in the presence of rapid structural change, industry location is affected by written regulatory stringency. Policy enforcement activity was shown to influence inventory decisions in general and larger operations were found to be more sensitive to willingness to enforce than smaller operations.

Keywords : Environmental Policy, Livestock Industry, Panel Analysis, Willingness to Enforce