A Nationwide, State-Level, Analysis of Animal Confinement Policy by Selected Species
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Abstract

We have addressed the impact of state environmental regulation on the livestock industry by selected two species. Beef cattle, as a leading livestock of the U.S, has experienced relatively steady structural transformation, on the other hand, hog industry has changed rapidly of its size and the location. The beef industry more or less sticks with traditional factors rather than regulation. On the other hand, the hog industry, which has more chance to adopt the stringency of state regulation during the special movement, is more sensitive by the stringency of regulation, especially in the large operation.

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Introduction

The impact of animal manure spread out on surface water, ground water, soil and air. Twenty-two states reported on the impacts of specific types of agriculture on rivers and streams, attributing 20 percent of the agricultural impairment to intensive animal feeding operation (USEPA, 1998). The public awareness of the potential environmental risk of animal industry is getting increased. Accordingly, state level environmental regulations are becoming more stringent with regard to animal feeding operations. However, the effectiveness and the real impact of the policy are not clear yet. This is either because of the difficulty of the analysis due to the data information or there are too many factors, which affect the structural change of livestock industry.

In recent, USEPA proposes to revise and update two regulations that address the impact by concentrated animal feeding operations (CAFOs) on water quality (USEPA, 2000). The National Pollutant Discharge Elimination System (NPDES) provides the definition of CAFOs and permit requirement of those operations. The technology-based effluent discharge standard, The Effluent Limitations Guidelines (ELG), for feedlot also has been provided. Depending on the size category, the structure of revised NPDES program has two alternatives, which are two-tier (>500 and <500) and three-tier (>1000, 300 to 1000 and <300). This is because the regulator wants to capture many possible factors whether the operation has a significant impact on the national water quality. From the policy prospective, the regulation by the size of the operation will be more effective, because the impact of the environmental regulation on the livestock industry will be different by size (Park, et. al).
In addition to the different impact by size, the different impact by species is one of the most important questions to the regulators and researchers. Due to the difference of the general industry characteristics, farm production and waste management practices, the result of policy implementation might be differ from species to species. During the last three decades, the structural change of the livestock industry gave us big attention on it. Even though fewer and larger operation dominates the all livestock industry, the feature is also different by species.

Even though fewer, larger and geographical concentrated animal feeding operation is a national trend, the future is different by species. Cattle farm, which needs more land relatively, are still dominated by small farm. The 56.7% of inventory of cattle was operated by small farm (>300 AU) in 1969, 51.4% in 1980 and 42.1% in 1997 and leading 10 states have 55% of total inventory. However, almost 80% of the hog inventory had been grown by small farm (>300AU) and there were no large operations (>1,000AU) in 1969, but in 1997, small farm is only 12.6%, and 61% of the total inventory is operated by large farm, which has over 1,000AU (Census of Agriculture, 1997). And 10 leading states operate more than 80% of total inventory.

The economies of scale may have derived the industry toward the fewer and larger operations, but also researchers have raised the possibility of different state regulation stringency may affect the industry change. Furthermore, we expect the impact of regulation should be different by size and species of the industry due to the different structural transformation. However, none of the researches has done of combining with the sizes and the species of the industry. The collective policy reaction of the industry can derive the effective policy and so, attain national water quality and sustainable
development of livestock industry. Here, we estimate different impact of state environmental regulation on the livestock industry by size (small, medium and large) and selected species (beef and hog) of the industry with the 36 states (97%) for beef and 29 states (98%) for hog during 29 years period.

**Economic rational and research reviews**

USEPA have regulated animal feeding operation almost 3 decades. It takes a cost to propose and enforce the new policy. Even after the enforcement, there will be additional cost due to the trial and error and monitoring of the operations. However, regulator usually expects more benefit than cost from the policy implementation through the protecting water quality and sustainable development of livestock industry.

Then, do we have enough evidence to prove the effectiveness of the state regulation? What if there is no direct impact of the policy on the industry? And so, the structural change of the industry was just due to the economies of scale and other socio-economic factor. Which mean that we may not need to spend the money to put forth the new policy any more. However, 128 billion pounds of manure each year from the livestock operation have threatened national water quality and public health and EPA propose updated NPDES and ELG, which are expected more effective, nationally consistent regulations to protect water resources.

In spite of the emerging and innovation of the animal confinement policy, little empirical evaluations of the policy have been done so far. Most of the researches emphasize on the one species to test the impact of the regulation on the livestock operation and it is dominated by hog industry. This is may be because the hog operation
is the most controversial specie in the livestock operations. Major proportion of the research is that the surveys of the changing structure of hog industry and the state environmental regulations rather than statistical analysis.

As indicated by many researches (Hurt and Zering; Martin and Zering; Hubbell and Welsh) the livestock industry is getting fewer and larger. Hubbell (1997) investigate geographic concentration of the U.S hog industry with an entropy based measure which comparing both between and within states. He found that the concentration is highest between-state, but within-state concentration for certain states (North Carolina) in high and increasing. However, the structural change of the industry seems not caused by the state environmental regulations (Martin and Norris). On the other hand, Martin and Zering discussed the relationship between industrialized agriculture and environmental consequences with broiler and hog production. They suggest that regulations may accelerate the industry toward larger and fewer, because economies of scale result in a greater cost per head of regulatory compliance for smaller operations. The timing and sequencing of policy signal make a different producers’ choice, so have a different impact on the farm, just like Texas and Florida dairy farm (Thurow and Holt). In resent, Metcalfe (2000) discusses the state’s manure legislation across states. He found that there has been significant increase in the general level of state legislation controlling animal industry. He also suggests that instead of the additional federal legislation, state or local regulations could be more efficient.

Compare to the manufacturing sector, there are only handful statistical analysis have tested about the impact of environmental policy on the livestock industry. Mo and Abdalla (1997) and Metcalfe (1999) test the impact of the regulation on the location of
hog farm. Traditional factors such as profitability and infrastructure are still important factors to decide the location of the inventory. However, there was no significant impact by the environmental regulations in general. As specific regulation enforcement, Matthey and Royer and Gow and Langemeier examined the impact of corporate farming laws on the Nebraska and Kansas hog farm. In both studies, regulations decrease the inventory of the region. It may suggest that the different results may be leaded by the difference between the general written stringency of the regulations and actual enforcement.

**Data and modeling**

*Data compilation and manipulation*

The hypothesis that stringent state-level regulation leads to decline in animal inventory is tested at the aggregate level for beef cattle and hog industry by 3 size categories. Additionally, small farms should be less sensitive, because the regulation usually targeting to the larger operation and hog farms should be more sensitive in the processing of structural change of the industry.

For this analysis, agricultural census data (NASS, 1997a) were compiled and manipulated from 38 states for beef cattle and 29 states for hog over almost three decades (1969 to 1997). 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) (Edelman et. al.). NASS “Historical Data” provided the source for the rest of the variables (NASS, 1999b). Data sources, units and variables are summarized in (Table 1).
Inventory per operation was segmented into three size categories broadly based upon federal policy norms to the extent that data allowed. These size categories reflect the standards set forward by the CWA. Values for non-census years were 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. The more available labor may bring more animals in the state. State unemployment rates were compiled and included, as a relative loose labor market might be expected to encourage industry expansion. As an indicator of industry transportation costs, annual beef and hog slaughtering capacity combined. Animal density is incorporated to measure whether the intensity of state animal bring more animal in the state or not. All of these variables are expected to correlate positively with total state livestock industry.

Table 1. List of Variables in the Analysis

<table>
<thead>
<tr>
<th>Variable</th>
<th>Units</th>
<th>Abbreviation</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inventory : Beef : Hog</td>
<td></td>
<td>Binven, Hinven</td>
<td>NASS, USDA</td>
</tr>
<tr>
<td>Animal-Corn Price Ratio : Beef : Hog</td>
<td>Bratio(B/C), Hratio(H/C)</td>
<td></td>
<td>NASS, USDA</td>
</tr>
<tr>
<td>Slaughtering Capacity (Beef&amp;Hog)</td>
<td>Lbs</td>
<td>Slaught</td>
<td>NASS, USDA</td>
</tr>
<tr>
<td>Land Value</td>
<td>$/acre</td>
<td>Landval</td>
<td>NASS, USDA</td>
</tr>
<tr>
<td>Unemployment Rate</td>
<td></td>
<td>Unemp</td>
<td>Census Bureau</td>
</tr>
<tr>
<td>Population Density</td>
<td>People/ Private land</td>
<td>Popden</td>
<td>NASS, USDA, Census Bureau</td>
</tr>
<tr>
<td></td>
<td>(1,000 acres)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animal density : Beef : Chicken</td>
<td>Head/Thousand Acres</td>
<td>Bexist</td>
<td>NASS, USDA</td>
</tr>
<tr>
<td>: Dairy</td>
<td></td>
<td>Cexist</td>
<td></td>
</tr>
<tr>
<td>: Hog</td>
<td></td>
<td>Dexist</td>
<td></td>
</tr>
<tr>
<td>: Hog</td>
<td></td>
<td>Hexist</td>
<td></td>
</tr>
<tr>
<td>Annual Average Precipitation</td>
<td>Inches</td>
<td>Precipt</td>
<td>NASS, USDA</td>
</tr>
<tr>
<td>Property Tax</td>
<td>$/acre</td>
<td>Protax</td>
<td>NASS, USDA</td>
</tr>
<tr>
<td>State Regulation Stringency Index</td>
<td>(0, 1, …, 19)</td>
<td>Regula</td>
<td>Task Force Survey</td>
</tr>
<tr>
<td>Fines Imposed</td>
<td>(0,1)</td>
<td>Levfine</td>
<td>Task Force Survey</td>
</tr>
<tr>
<td>Staffing Level</td>
<td>(FTEs)</td>
<td>Staff</td>
<td>Task Force Survey</td>
</tr>
<tr>
<td>Anti-Corporate Farm Law</td>
<td>(0,1)</td>
<td>Corp</td>
<td>Task Force Survey</td>
</tr>
<tr>
<td>Local Agricultural Zoning</td>
<td>(0,1)</td>
<td>Zoning</td>
<td>Task Force Survey</td>
</tr>
</tbody>
</table>
In an attempt to come to terms with potential covariance between the population density and the size of the livestock industry, we compiled 5 years Census (1960, 1970, 1980, 1990 and 2000) population data on the state private land. Potentially, we expect that the higher population density in the state, the less animal inventory growth in that state.

As an either fixed or sunk cost, state’s land value might be a initial condition of the choice variables, in spite of the trend of concentrated animal feeding operation, so less land use. Just like the land value, state’s property tax also should be considered as a business climate of the state. The state’s annul average precipitation were taken into account to present the different state climate and environmental vulnerability. All of three variables are expected negative correlation with the state animal inventory.

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. 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 were included.
Methodological Approach

The analytic methodology is based on the components model, which is specified as:

\[ Y_{it} = X_{it} \beta + Z_{it} \gamma + \alpha_i + \eta_i \quad (i = 1, \ldots, N; t = 1, \ldots, T), \]

where the vectors \( X_{it} \) and \( Z_{it} \) are time-varying and time-invariant variables respectively. The \( \alpha_i \) represents the unobservable effect believed to exist across units, while the \( \eta_i \) 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 \( Z_{it} \) 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 \( \alpha_i \). Hsiao 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 suggests that the \( \alpha_i \) should generally be considered random effect. Other factors can be a determinant of this estimation decision as well. For example, the estimates of the \( \beta_i \) become 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 \( \hat{B}_w = (X'Q_vX)^{-1}X'Q_vY \). The \( Q_v = I_N \otimes i(i')^{-1}i' \) is a projection operator that takes deviations from the unit mean of each variable in the \( X \) or \( Y \) matrices. Thus,
(\(Q_v X\))_i = (X_{it} - \bar{X}_i) \) and \((Q_v Z)_i = (Z_i - \overline{Z}_i)\); as Hausman and Taylor 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 \(\gamma\), 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, a two-stage method by Alvarez and Gonzalez can be used for estimating \(\hat{\gamma}_i\) 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 \(\alpha_i\) and \(\eta_i\), and a derived value, \(\Theta\). Let

\[
\sigma^2 = \text{plim}_{N \to \infty} \frac{1}{N(T-1)} \eta_i' Q_v \eta_i.
\]

\[
s^2 = (1/N) (Y_i - X_i \hat{\beta}_w - Z_i \hat{\gamma}_w)' (Y_i - X_i \hat{\beta}_w - Z_i \hat{\gamma}_w).
\]

\[
\sigma^2 = s^2 - (1/T)\sigma^2_n.
\]

\[
\Theta = |\sigma^2_n / (\sigma^2_n + T\sigma^2_a)|^{1/2}.
\]

where \(\sigma^2_n\) 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 \(\sigma^2_a\) in the third equation. The \(\hat{\beta}_w\) and the \(\hat{\gamma}_w\) are the WITHIN estimates for the time varying and time invariant coefficients.
respectively (the latter to be discussed below). The \( Y_i = (1/T) \sum Y_{it} \) and the \( X_i = (1/T) \sum X_{it} \) are the unit means, averaged across all time periods for the dependent and independent variables. These variances are used in calculate a weighting variable, \( \Theta \), 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).²

For a given observation, the \( \Theta \) is used to create the weighting matrix \( \Omega^{-1/2} \) used in GLS transformation.

\[
\begin{align*}
\Omega^{-1/2} &= \Theta \hat{P}_v + \hat{Q}_v = I_{N} - (1 - \Theta) P_v \\
\Omega^{-1/2} &= \Omega^{-1/2} X_{it} \beta + \Omega^{-1/2} Z_i \gamma + \Omega^{-1/2} \alpha_i + \Omega^{-1/2} \eta_i \quad \text{or} \\
Y_{it} - (1 - \Theta) Y_i = [X_{it} - (1 - \Theta) X_{it}] \beta + \Theta Z_i \gamma + \Theta \alpha_i + [\eta_{it} - (1 - \Theta) \eta_i].
\end{align*}
\]

*(\( P_v \) makes vector of group mean, so \( P_v Y_{it} = (1/T) \sum Y_{it} = Y_i \)).

The above equations show that the random effects estimator differs the data after a fashion, depending on the value of \( \Theta \). At one extreme, if \( \sigma_{\alpha_i}^2 \) were zero, then \( \Theta \) goes to 1, and GLS becomes ordinary least squares, as the \( Y_i \) and \( X_{it} \) terms drop out. If \( \Theta \) equals zero, then \( \sigma_{\eta_1}^2 \) is zero, and all variation across units would be due to the \( \alpha_i \); 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 are affected, as they enter OLS in their original form when \( \Theta \) is 1 and drop out of the equation when \( \Theta = 0 \).

The estimated \( \Theta \)s are presented in the Table 2 and it indicates that the \( \sigma_{\eta_1}^2 \) is almost zero and goes to fixed effect model. However, we can’t estimate \( \gamma \) in the fixed

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² Our presentation is based on Hausman and Taylor’s definition of \( \Theta \), which is equivalent to Greene’s \( \lambda \). Greene also used a \( \Theta \), where \( \lambda = 1 - \Theta \) in his terminology. This is just another indication that industry standards have not totally reached the econometrics literature.
effect setting and we lose all time invariant variables, which is our most interested variables.

Table 3: Estimated θ for each group

<table>
<thead>
<tr>
<th>Species</th>
<th>Total</th>
<th>Small</th>
<th>Medium</th>
<th>Large</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef</td>
<td>0.02</td>
<td>0.03</td>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td>Hog</td>
<td>0.06</td>
<td>0.04</td>
<td>0.04</td>
<td>0.07</td>
</tr>
</tbody>
</table>

Therefore, we conduct two-step estimator, which was developed by Alvarez and Gonzalez. The first step is to estimate a fixed effect panel data model with all time-varying variables. The model is

\[ Y_{it} = \alpha + X_{it} \beta + \eta_{it} - \nu_i \quad (\alpha_i = \alpha - \nu_i) , \]

where \( \alpha_i \) is the fixed effects of each cross-section units.

In the second step, we can adjust the \( \hat{\alpha}_i \) by regressing them 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 \( \alpha_i \) 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.

\[ \hat{\alpha}_i = Y_{it} - X'_{it} \hat{\beta}_w = [P_v - X_{it}(X'_{it} Q_v X_{it})^{-1} X'_{it} Q_v \]
\[ = \alpha + Z'_{it} \gamma + \nu_i + [P_v - X_{it}(X'_{it} Q_v X_{it})^{-1} X'_{it} Q_v \] \( \epsilon_{it} \).

The dependent variable \( (Y_{it}) \) is specified beef cattle and hog inventories by categorical size in a state in a given year. The matrix of independent state characteristic variables \( (X_{it}) \) consists principal categories: Following Mo and Abdalla, the independent
variables were organized into Natural Endowments (1), Economic Factors (3), Business Climate (3). The matrix of \((Z_i)\) specifies the stringency of state environmental policies (5), which are time invariant.

**Results**

As we expected, the results were different in the all stage of analysis by species and size of the industry. Based on the EPA’s three-tier norm, the estimated results are reported by three sizes (Small, Medium and Large operations) of beef cattle and hog farm (Table 3 and Table 4).

The state’s natural endowment and business climate seem to have expected impact on the on the small farm in both beef and hog operations. The unemployment rate increase the number of hog in the small and medium farm, and also beef in the small farm. On the other hand, there is decreasing number of head in the medium and large for beef and in the large for hog farm. Property tax of farmland per acre and precipitation has a significant negative impact on the small beef farm and also negative impact on small hog farm but insignificant. Unexpectedly, property tax gives an increment of large beef inventory and precipitation has not significant impact on the large operation in both beef and hog. Land value, as a sunk cost of the industry, seems to increase the state inventory in general, except the small hog farm.
Just like the production of the other agriculture, animal industry has less tied to its natural resource (Mo and Abdalla; Gow). Traditionally, animal industry location usually sticks with the corn-belt area to achieve the cheap input cost. Technology innovation is adopted by large operation, which is possible to provide the financial assessment. Therefore, small farm, which is hard to obtain the economies of scale still dominated by traditional factors, but large farm is less bounded to the location of the natural resources through the new technology.
Industry location is subject to conflict not only with population density, but also the other specie itself of the state. However, the responses differ from by species and size of the industry. Beef industry does not have confliction with population density, except medium farm. However, hog farm has a tendency to be located at the less population density state in general, except small farm. Even though cattle industry needs certain size of minimum farmland, there is increasing number of cattle on feed in nation wide, and traditional nostalgia may make less conflict. On the other hands, hog, which is most controversial specie in the states (Edelman et al.), has strong negative impact by the state.
population density in all size of the industry, except small operation. Generally, beef industry does not look like to conflict with other species density within the states. However, hog industry, especially medium and large operations seems not to locate in the state, which is leaded by dairy and beef cattle operation and more or less concentrated in the high hog density state.

The state economic factor, which represents the profitability, industry looks like to follow the traditional rule. The higher the ratio of beef/corn and hog/corn price ratio, the higher beef and hog inventory respectively. The state slaughtering capacity has a significant positive impact on the large operation in both species, but not for small and medium beef and small hog industry. Even though well-linked interstate can reduce the transportation cost of the industry, it is more profitable to be within a certain area.

A lot of important futures have founded with the environmental policy variables. It shows not only the correlation, but also causality between the regulation and industry structure. Even though, we could not accept our hypotheses fully, but the stringency of the regulation and the state willingness to enforce have an impact on the livestock stocking and location decision.

The industry reaction varies by species and size of the operation. (Park et al.) Shows that the written stringency of the regulation has a positive impact on the total animal industry (Beef, Chicken, Dairy and hog), which was not surprising. The industry externalities usually call the state regulations, so the more animal inventory in the state, the higher the regulation index. However, species analysis indicates large hog operation significantly reduced the number of head by the state environmental policy. The regulation is stringent in regard to large hog operation. It seems to be directed and
enforced at this operation, such as moratorium could be imposed just on large hog operation. As we know, the beef industry is more stable, which means that the traditional factors have led industry location. However, the hog industry has experienced relocation through the vertical coordination and concentration, so it is possible for the industry to react more to avoid state regulation when they relocate. It is hard to take into account the environmental compliance cost to the existing industry due to the fixed cost, but in the process of relocating, stringency of the regulation will be one of the most important factors considered by the industry.

As a willingness to enforce of the state regulation, full-time staff and levied fine has different results by species and size. A number of staff significantly reduces the inventory for beef and hog in general. The reason may be simple, because most of the full-time staff is working in the leading hog states and less beef in those states. This result also shows that industry induces the state regulation.

Levied fine is not significant for beef industry, but significantly positive for hog in general. Fine usually imposed to the hog industry by full-time staff of the state and seems no correlation with beef industry. Fine will be imposed in the leading hog states to prevent excessive spill over, and if industry, usually large farm, fails to follow the regulator’s guidance, it is possible to have negative impact on the large hog operation by the fine. And this result may give an indirect positive impact to small and medium farm. As noted earlier (Thurow and Holt, Martin and Zering), regulation agency (staff) derives for industry to adopt Best Management Practices (BMPs) and technology innovation, which makes sustainable development of hog operations. If not, EPA’s regulatory norm
usually targets to large operation except some cases, and it is not difficult to see that hog operation is more sensible to the state regulation.

States anti-cooperation law constrains the structural change of the industry toward the larger operation. The structural change of the industry has leaded by large hog operation and anti-cooperation law usually constrains more large hog than beef operations and does not allow it within the state. On the other hand, it is correlated with increases in the overall beef and also small and medium hog inventory. As Matthey and Royer pointed, it is hard to assess the real impact of legal restriction due to the dynamic future of the economy. However, the choice of the society to prevent the environmental degradation looks enough to slow down the increment of larger and concentrated hog operations.

Agricultural zoning regulation increases the size of the industry in both species and in all size of the operation, but not large hog farm. The state right to farm seems to work well in all size of beef and hog industry, except large hog farm. Beef industry and small and medium hog farm are ruled by Agricultural zoning regulation, because there was no significant structural change, so does no unexpected negative impact. However, significant increment of large hog farm is expected excessive externalities, and it may not be ruled by Agricultural zoning regulation anymore. And also large hog operations may not be considered as an agricultural production anymore.

**Conclusion**

It may be hard to define the relationship between the structural change of livestock industry and state environmental regulation in general. This is because not only
the complexity of the relationship, but also the lack of information from both regulator and industry. However, the species comparison gave us the interesting futures about the different impact based on the different industry structure. We have addressed the impact of state environmental regulation on the livestock industry. The different state regulation will lead different business climate to the industry and therefore the relationship is important issues to the industry, local economy and environmental prospective.

Two major species was selected to test whether the regulation has different impact by industry specific characteristics. Beef cattle, as a leading livestock of the U.S, has experienced relatively steady structural transformation, on the other hand, hog industry has changed rapidly of its size and the location. Our questions were that what’s the relationship between state-level environmental regulation and performance of beef and hog sub-sectors? And, does the impact differ by species and size of operation? Finally, does the impact of willingness to enforce differ from written stringency?

We expected the more stringent regulation, the higher the environmental compliance cost. Therefore, the test hypothesis was that “stringent state-level regulation leads to decline in animal inventories in the state.” In addition to, EPA usually targets toward larger and concentrated farm, so small farm should be less sensitive. And hog farm should be more sensitive due to the rapid structural change. The difference of the industry futures gives us the different results. Traditional factors are still important predictor of location and stocking decisions. Even though the importance of state regulations is getting increased, traditional factors are important for the decision making especially on the beef industry. Generally, regulations seem to be induced by the structural change of industry to internalize the externalities within the society with the
policy tools. However, regulation also induces the industry through the state’s willingness to enforce and the impact is differ from the species. The environmental compliance cost may be a small portion of industry total cost and fixed cost of beef industry makes difficult for them to take into account environmental compliance for their decision making. On the other hand, the special movements of hog industry through the technology and vertical coordination have chance to minimize the cost of the operation and they willing to locate less stringent place. Meanwhile, concentrated state regulation on the large hog farm results indirect positive impact on the state’s beef industry and smaller hog farm in some cases in the analysis.

From the policy prospective, the effectiveness of the policy should be determined by whether the policy directed and enforced with the minimum cost to achieve the national goal. In our sense, livestock regulation need to be more localized and specialized by the size and species of the states to account the each characteristics. For better understanding of relationship between the regulation and industry, we need to specify the new entry and exit of the industry and dynamic change of state regulation in the future.

References


