THE IMPACT OF ENVIRONMENTAL REGULATION ON THE GROWTH OF THE UNITED STATES HOG INDUSTRY

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TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

Background

Under the traditional system of livestock production in the U.S., small numbers of animals have been raised in many different places. Because they were so widely dispersed it was presumed that the wastes produced caused little environmental degradation. Livestock production operations are now often large, fewer, and operated on smaller acreage. This move may have been fueled by economies of scale, specialization, regional concentrations and many different forces.

Technological change has enabled the hog industry to move hogs indoors, adopt all-in/all-out production, segregate early weaning, and initiate feeding and terminal breeding programs (Plain). The number of pigs weaned per litter, as reported in the U.S. Department of Agriculture's December 1996 *Hogs and Pigs Report*, reflects the interaction of technology, production efficiency, and firm size. Pigs saved per litter in 1996 by size of operation ranged from 7.30 for operations with 1-99 hogs to 8.80 for operations with more than 2000 hogs and pigs. In the U.S. the total number of hog operations of 157,450 in 1996 is down 13 percent from 1995 and 24 percent from 1994. During this same period, operations with 2000 or more hogs accounted for 3 percent of hog farms and 51 percent of the total inventory.

Table 1. U.S. Hog Inventory and Number of Farms

Year	Total Inventory (millions)	Number of Farms (thousands)
1988	55.5	322.6
1989	53.8	300.9
1990	54.4	268.1
1991	57.7	247.1
1992	58.2	240.1

Source: USDA Hogs and Pigs Report: Final Estimates 1988-1992.

Table 1 shows a progressive decline in the total number of hog operations even as hog inventory continues to increase.

The U.S. hog industry has also witnessed structural change based upon the separation of the functions of ownership, management, and labor. This is reflected in the increasing number of hogs raised under contract. In 1996 the total number of hogs under contract, owned by operations with at least 5000 hogs and pigs but raised by contractees, accounts for 21 percent of the U.S. hog inventory (USDA). Among the largest hog producers there has also been some vertical integration, with production, slaughter and packing as the main activities. As packing plants become larger but fewer, the problem of proximity is pushing some hog producers farther from competitive markets. The total number of hogs slaughtered in the U.S. since the Federal Water Pollution Act of 1972 rose from 85 million that year to 99.2 million in 1996.[1]

[1]All production data were obtained from the National Agricultural Statistical Service of the United States Department of Agriculture.

U.S. Corn Belt hog producers had the largest share of hog farms and sales, although hog farms in the plains states had the highest average land area (USDA). Among the top ten hog producing states in the U.S. in 1996 are Iowa, North Carolina, Minnesota, Illinois and Indiana.

While the total inventory of hogs in the U.S. declined 4 percent between December 1995 and December 1996, some states registered rapid increases in hog inventory over the same period: 132 percent in Oklahoma and 263 percent in Utah. Projecting current trends indicate that North Carolina will overtake Iowa as the top hog producing state in the U.S. by the year 2000 (Plain).

Problem Statement

Wastes from confined animal feeding operations are a major source of both point and nonpoint agricultural pollution. The amount of wastes generated by large concentrated animal feeding operations is huge. The method of manure storage, the treatment facilities available and the land application rates generally determine how the environment may be affected. The most common manure storage facility used by U.S. hog producers in 1992 were manure pits, and larger operations tend to locate such facilities farther from houses, wells and surface water (Plain). In many states livestock wastes may be applied to the land in solid or liquid forms. When land application is carried out without regard to time, rate and method, such applications might result in water quality degradation.

The public has become increasingly concerned about potential effects of Concentrated Animal Feeding Operations (CAFO) on the environment. The Sparks Companies Incorporated (SCI) policy report of May 15 1997 (pp. 2) aptly states the frustrations of the citizenry and their elected representatives:

> In recent months, North Carolina's (hog industry) growth has led to worsening environmental problems and growing criticisms of hog farm waste management, water pollution and odor problems. Not only has much of the luster now gone from the sub-sector's glamour, but key state officials are actively moving to restrict future growth, at least temporarily. A bill to halt construction of large hog farms in the state was recently introduced in the legislature, a move that has the backing of the governor who earlier proposed a two-year moratorium on expanding the booming industry.

Where pollution externalities exist, governments may intervene by developing policy measures to improve social welfare. One way to control such externalities is the frequently proposed system of unit taxes in which the tax is equal to the marginal social damage. Although such Pigouvian taxes yield Pareto optimal resource allocations in competitive systems, they are rarely used because the social damage due to pollution is difficult to measure, and available data are related only to the neighborhood of the economy's initial position (Hochman and Zilberman). An alternative strategy (Baumol and Oates) sets an arbitrary standard of environmental quality and imposes taxes to attain this standard. This hardly attains a Pareto optimal solution, but it may achieve the desired level of pollution at minimum cost to the economy.

Since the Federal Water Pollution Act of 1972, there has been a spate of federal, state and local regulations designed to protect the country's water, air and land from environmental degradation. The Federal Clean Water Act, which prohibits the discharge of any pollutants into U.S. waters from point sources, is considered the most significant legislation impacting U.S. livestock producers (Gates). Such regulations are generally based on standards, and may not consider the costs of compliance or the regulation's effectiveness in maintaining high water quality. The regulation costs incurred by producers often affect economic viability and competitiveness of the livestock industry. Effectiveness and enforceability of new regulations, as well as their effects on location, size, and competitiveness of the livestock industry may not be adequately determined without reference to compliance cost estimates and information to predict the effectiveness on water quality (Christensen and Krause).

The Environmental Protection Agency (EPA) retains jurisdiction over some states in the enforcement of its federal regulations, while it delegates enforcement responsibility to competent authority in other states. States also develop and enforce regulations for point and nonpoint sources; many of these programs are voluntary (Letson and Gollehon). Regulation of livestock operations by individual states has been inconsistent even among states to which EPA has delegated National Pollutant Discharge Elimination Systems CAFO permitting authority (Frarey and Pratt). The existing differences in application and enforcement of environmental regulation among states combined with natural resource endowments and taxation policies probably impact the hog industry. The research question will be: How do differences in livestock waste regulation policies among states affect location and size of the hog industry in the United States?

Objectives

The general objective of this study is to determine the impact of differential application and enforcement of federal, state, and local livestock waste regulation policies on the growth of the hog industry in some top hog producing states in the US.

The study has the following specific objectives:

1. To develop a matrix of environmental regulations for some major U.S. hog producing states, drawing out the differences and similarities.
2. To describe some of the structural characteristics of the U.S. hog industry, showing current changes and future developments.
3. To determine the effect of livestock waste regulatory and tax policies on inventory, location and size of the hog industry.

CHAPTER II

THEORY AND LITERATURE REVIEW

Conceptual Framework

Agricultural pollution is a classic case of external diseconomy in which the welfare loss is uncompensated. Increased per capita income in developed countries has led to increased demand for income-elastic goods such as environmental amenities (Reichelderfer and Kramer). However because consumers have little independent market power regarding environmental repercussions of farming, governments intervene as representatives of non-market demand with regulations designed to internalize the external costs of production and preserve public goods.

Although taxation has been recognized as a first-best policy that maximizes producers' and consumers' surpluses in environmental regulation, standards have been preferred by policy makers because taxes result in lower output and higher prices (Hochman and Zilberman).

The static deterministic production function is an unidentified mathematical function of hog inventory Y, a vector X_k of k non-renewable variable inputs, and a vector X_j of j natural resource input flows:

(1) $$Y = f(X_j, X_k).$$

For a hog operation which also generates a negative externality the second output, pollution, is represented as:

(2) $$Z = h(X_j, X_k).$$

Because many livestock waste regulations emphasize reduction in pollution levels rather than abatement, this model will not include pollution abatement costs. A joint product profit maximizing hog operation would have the following profit function:

(3) $$\pi = P_y f(X_j, X_k) + P_z h(X_j, X_k) - P_j' X_j - P_k' X_k - b,$$

where P_y is the price per hog, P_z is the price (or social cost) of pollution, and P_j, P_k and b are costs of inputs X_j and X_k and fixed production costs, respectively. Where the polluting animal feeding operation remains unregulated, the marginal social cost of pollution remains uninternalized, and a virtual non-existent cost to the producer. In the regulated industry it becomes the internalized cost of pollution. A social welfare analysis can determine the socially optimum level of pollution, and the optimum penalty to levy when a firm violates the restrictions. The decision rules under unconstrained profit maximization indicate that the inputs' values of marginal products are equal to the sum of the value of marginal damage due to pollution and the price of the input. A solution of the simultaneous first order equations gives an estimate of the socially optimum pollution level Z^*. With this constraint the hog operation's profit maximizing function is given as:

(4) $$\pi = P_y f(X_j, X_k) - P_j' X_j - P_k' X_k + \lambda(Z^* - h(X_j, X_k)).$$

No-discharge states would set the socially optimum pollution level at zero, and differential application of environmental regulations implies that different states would have different social optima. The firm's marginal cost of pollution abatement or the optimum penalty for non-compliance is λ.

The decision rules from (4) would suggest that the hog operations' optimum pollution level should be equal to the social level. The optimality conditions are supposed to set a standard for first-best performance. It is however clear that as long as the optimum pollution level is set without regard to size of operation (assuming this is directly proportional to amount of pollutant) it would be deemed inefficient. Differential application of regulations could imply different social optima of pollution level, and, ultimately different costs of compliance in different states. These influence producer decisions on where to operate, and how much to produce.

In the absence of adequate information, standards are however preferred to taxes because they prevent effluent levels from increasing when costs turn out to be higher than initial estimates (Spence and Weitzman). Regulations would constrain concentrated animal feeding operations such that appropriate reductions in pollution are achieved, by placing restrictions and imposing costs on the regulated industry.

Historical Perspective of United States Water Pollution Control Policy

This non-exhaustive history of environmental regulation in the U.S. livestock industry dates in recent times to the 1898 Refuse Act. This Act prohibited discharges that would hinder navigation, and required federal permits from the U.S. Chief of Engineers for dredging and disposal of dredged material. With the Water Pollution Control Act of 1948 came the federal government's first move to control water pollution. Although it reaffirmed state and local responsibility for controlling water pollution, this act initiated federal government authority to conduct investigations, research and surveys. Tenets of current water pollution control policy can be recognized in two provisions of the 1956 amendment to the Federal Water Pollution Control Act:

First, federal financial support for the constructing waste treatment plants was assured. This provision grants municipalities up to 55 percent of the cost of constructing water treatment facilities from federal grants. Second, direct federal regulation of waste discharges was to be put in place. This provision authorizes the designated federal control authority to convene a conference to deal with any interstate water pollution problem.

The Water Quality Act of 1965 was an attempt to improve on this process by establishing ambient water quality standards for interstate water courses and by requiring states to file implementation plans. States responded by drawing up plans that were vague and did not attempt to link specific effluent standards on discharges to the ambient standards (Tietenberg).

Present pollution control policy in the U.S. derives from earlier policies and programs aimed at industrial and municipal sources. Since implementation of the Federal Water Pollution Control Act amendments of 1972, agriculture has become a significant part of the programs (TIAER). Also known as the Clean Water Act, this act divides water pollution sources into point and non-point categories and sets water quality standards which states would eventually implement through regulatory programs (Jones and Sutton). Whether developed by states or by the Environmental Protection Agency, the essence of the regulations is to control feedlot runoff, require properly designed earthen structures with adequate storage, and recommend rates of manure application to cropland. The initial regulatory focus of the Federal Water Pollution Control Act amendments of 1972 was to control livestock and poultry operations as a point source of water pollution (Smith), even though agriculture is considered the greatest contributor to nonpoint pollution. Concentrated Animal Feeding Operations (CAFO) are the only type of agricultural production operation regulated by the Environmental Protection Agency or the delegated states under the National Pollutant Discharge Elimination System (Frarey and Pratt). Under the NPDES all feedlots with more than 1000 animal units, and with a discharge other than during the 25-year, 24-hour storm event must obtain a permit. A NPDES permit is also required for feedlots that have from 300 to 1000 animal units with a direct discharge through a man-made conveyance or with a stream running through the feedlot. Many states were granted authority by the EPA to draw up their own programs; the required state manure management plans must be more stringent than the NPDES program. CAFOs have been treated as relatively low priority compared to industrial and municipal point sources, by the EPA and many delegated states. Small wonder that in 1992 less than 10 percent of the estimated 10,000 livestock operations sufficiently large to be classified as CAFOs held NPDES permits (Frarey and Pratt). Among delegated states there is considerable discrepancy in the implementation of the NPDES program (Frarey and Pratt, Muehling).

The most important issues in local control of livestock production include nuisance complaints and right-to-farm laws, special protection districts such as agricultural areas and, local land use controls such as county and municipal zoning (Hamilton). Although right-to-farm laws are deemed necessary to protect farmers from frivolous civil suits, they are being reauthorized by many states making them conditional on compliance with state environmental regulations. In spite of the Coastal Zone Management Act (CZMA) of 1995, agriculture as a non-point source of water pollution has remained largely unregulated.

Socioeconomic Impact of Environmental Regulations in the U.S. Livestock Industry

Technology and the changing structure of animal agriculture have led to a call from the citizenry for greater stewardship of the environment. The public is particularly concerned about air quality, degradation of streams from nitrogen, phosphorus, and pathogens and pollution of ground water from nitrogen (Christensen and Krause). Farmers operate in a world of short-term economic pressures and farm programs that emphasize maximizing present production, practices that ironically may not foster environmental stewardship (Hamilton). Under a maze of federal, state and local regulations, producers must manage farm resources to maximize profits while at the same time ensuring that livestock wastes do not contribute to environmental pollution or exceed permit standards.

There are conventional arguments (Bartik) that regulatory costs are quite small compared to other business costs such as labor costs, and hence do not play an important role in business location. Bartik's own study of manufacturing plants found no statistically significant effect of state environmental regulations on the location of new branch plants. Results from studies of livestock operations are mixed. Although not conclusive, one study (Mo and Abdalla) reports that state environmental policies were a significant factor influencing hog production growth. Bartik, and Mo and Abdalla, used different proxy variables as measures of environmental regulation, or the stringency thereof. Another study (Knutson, Outlaw and Miller), using a completely different methodology from Bartik, and Mo and Abdalla, observed that for the vast majority of relatively profitable dairies, EPA regulations have no adverse impact. The study, however, concludes that if a dairy is already experiencing cash flow problems, compliance with EPA regulations could push this farm over the brink into financial failure. Dairy farmers that are bringing their farms into compliance with the new EPA standards could find it desirable to simultaneously expand their dairy operations.

The regulated industry could implement environmental policy if the cost of implementation is relatively low, and cost sharing practices are readily available (TIAER). However such cost sharing practices may reduce profit margins for highly competitive firms, and reduce the availability of capital for other functions of the firm. Agricultural producers from all sectors are now suggesting that as price takers, they are generally unable to pass on the costs of environmental regulation to consumers of their products (Davidson). Earlier studies (e.g. Meier) suggest that dairy farmers are no different from producers of the least regulated commodities in their inability to recover pollution control costs from the market.

Several studies have focused on the shortcomings of current methods of regulating polluting industries. Some of these studies (Harrington, Krupnik, and Peskin; Savage; Thomas;) point to the ineffectiveness of existing programs for non-point source water pollution abatement given the leading role of agriculture as a non-point source in water quality problems. Shortle and Dunn suggest that, if policy transaction costs were set aside, an appropriately specified management practice incentive should generally outperform estimated runoff standards, estimated runoff incentives, and management practice standards for reducing agricultural non-point source pollution. Hochmann and Zilbermann advocate a predetermined quality target that may be obtained by imposing taxes via an iterative procedure which eventually converges to a unique and stable equilibrium. This procedure is considered by some as an improvement on the Pigouvian tax concept in pollution control.

It has been observed that impact studies in environmental regulation show consistent results depending on methodology. According to Gray and Shadbegian growth accounting studies generally find small impacts because compliance costs constitute a small share of total costs, while studies which use regression have often found significant effects between regulation and productivity. Their own study of environmental regulation in the pulp and paper, oil, and steel industries showed a strong connection between regulation and productivity when regulation is measured by the plant's pollution abatement expenditures. Plants with higher compliance costs had significantly lower productivity rates. Gollop and Roberts suggest that one effect on productivity growth of environmental regulations is that it diverts much needed resources from the production of marketable output to the satisfaction of emission constraints. Such regulations would reduce the level of scale economies or, equivalently, reduce the cost benefits of large scale operations. It remains to be seen how the hog industry could be affected when most of the operations are small.

Environmental regulations are not only measured in monetary costs but also in attendant uncertainty. One study (Vicusi) suggests that regulations influence current enterprise decisions not only through their current output level but also through their expected future level and the degree of uncertainty regarding future regulatory policies. But the impact of regulations does not only stop at measurement effects. Regulations impose constraints on the firm's choice of production decisions makes it harder to take advantage of new innovations, cause firms to lower new investment by increasing uncertainty or otherwise reduce the productivity of other (noncompliance) inputs. Gray suggests that the effect of EPA regulations is relatively weak compared to those of OSHA on productivity growth. Christiansen and Haveman evaluate the contribution of public regulations to the slowdown in productivity growth. Their results show that federal regulations were responsible for 12-21 percent of the slowdown in the growth of labor productivity in US manufacturing during the 1973-1977 period.

As earlier stated results on the impact of environmental regulation are in some respects sensitive to the manner in which the model is specified. Barbera and McConnell estimated a system of factor demand equations as opposed to the previous approach of total factor productivity, to allow including an important component of firm behavior, factor demand. They also found out that environmental regulations slowed productivity growth, and that the most heavily regulated industries experienced relatively large negative productivity changes.

Jorgensen and Wilcoxen analyzed the impact of environmental regulations by simulating the long term growth of the U.S. economy with and without regulation. The sectors hardest hit by environmental regulations did not include agriculture, forestry, and fisheries. These remained largely unaffected or only moderately affected by environmental regulations. However Conrad and Robinson envision declining international competitiveness in the U.S. because of environmental regulations.

Most of these studies, though highly relevant were done in industries other than agriculture, where it has been consistently less difficult to measure or define environmental regulations. While many have shown that environmental regulations significantly lower productivity growth, some have suggested that environmental regulations may actually facilitate economic growth. Meyers and Nakumura used a putty-clay model to show that it is possible for increasingly stringent environmental regulations to cause more capital turnover, and therefore, modernization, so that the net effect may be increased productivity of growth.

CHAPTER III

DATA AND METHODS

Overview

This chapter covers sources of data and the analytical procedures employed. We recognize that it is generally difficult to quantify measures of environmental regulation because of possible endogeneity of state environmental regulations and other policy choices of state and local government (Bartik; Christiansen and Haveman). Christiansen and Haveman even lamented the difficulty of defining such measures.

The focus of this study rests with the proxy variable for environmental regulation, the Green Index, and its impact on growth in the hog industry. Developed by Hall and Kerr during the period 1991/1992, this index which is shown in the table below, is comprehensive, constituting 256 indicators which measure and rank each state's environmental health. A higher total index indicates low environmental quality, which may in turn be due to non stringent enforcement of regulation, or the absence of it. This should in turn have little or no adverse effect on the hog industry. To make our measure of environmental regulation more relevant we used only five years of annual data, from 1988 to 1992, aggregated for fifteen of the United States' major hog producing states.

Table 2. The Green Index 1991/1992

State	Total Green Index	Rank
Georgia	7488	39
Illinois	7052	31
Indiana	7939	43
Iowa	6541	20
Kansas	7732	42
Kentucky	7694	41
Michigan	6297	17
Minnesota	5000	5
Missouri	7006	30
Nebraska	7001	29
North Carolina	6772	23
Ohio	7411	37
Oklahoma	7644	40
Pennsylvania	6905	26
South Dakota	6965	27
Wisconsin	5478	10

Source: Green Index: A State by State Guide to the National Environmental Health 1991/1992.

The Green Index represents a broad view of environmental quality and its 256 indicators evaluate the different consequences of how people machines and nature interact across the nation (Hall and Kerr). A rank of 50 is the worst and rank 1 is the best.

But regulation itself may also exist in the form of taxation. For this study the proxy for this variable is the farm real estate tax per $100 of farm real estate value.

Hog inventory is the total number of hogs in each state (breeding inventory and marketing inventory). Changes in hog inventory measure hog industry growth. This study will determine the effect of regulatory and taxation policies on size and location of hog industries. Empirical evidence from the National Agricultural Statistical Services (NASS) of the U.S. Department of Agriculture suggest that there is differential growth in hog inventory across the U.S. Some have argued that there are considerable discrepancies in regulations and enforcement among states (e.g. Pratt and Frarey, Muehling). These analyses are based on the premise that applying environmental and taxation policies more stringently leads to higher production costs, and lower profit margins. Consequently livestock operations will thrive in states with lower regulatory burdens. With economies of scale and specialization such operations will eventually become large and concentrated, as they strive for profitability. Whether this is true or not is the object of this study.

Summary of Environmental Regulations in the U.S. Hog Industry

The matrices in tables 3 and 4 show a summary of regulations affecting the hog industry in ten hog producing states. When the Clean Water Act was first passed it was intended to control non-point sources of water pollution. Hog operations would be targeted under this regulation. The Environmental Protection Agency's National Pollutant Discharge Elimination System permit program was to be implemented by state agencies. States would also be required to draw up manure management plans that were more stringent than the NPDES program. The NPDES permit would be required for hog operations with no less than 1000 animal units, and for operations with 300-1000 animal units which have a direct discharge into U.S. waters. Zoning requirements should have kept odor and nuisance problems in check. Under CAFO regulations one animal unit for swine, is one swine (over 55 pounds) multiplied by 0.4. Therefore 1000 animal units is equivalent to 2500 swine (over 55 pounds).

The review did not exhaustively cover the current status of regulations; it has only been used to show some of the differences and similarities among the states reviewed. It covers requirements for the permit system, and in some cases penalties for permit violations.

There are state agencies responsible for environmental regulation. In some states e.g. Arkansas, Georgia, and Pennsylvania the responsibility rests with multiple agencies. This does not necessarily translate into more stringency of regulation.

The EPA delegated CAFO permitting authority to some states, and not to others. NPDES (general) and state permits are required in most states. Some states require that hog farmers obtain multiple permits: construction permits; operation permits; wastewater treatment permit; water use permit; etc. Although CAFO regulations recommend the 1000 animal unit threshold for NPDES permit requirement, many states have adopted lower cutoff figures e.g. 750 swine (over 55 pounds) instead of 2500.

For most states NPDES permit applications must be accompanied by a certified pollution prevention plan. In many cases they detail design criteria for waste sites included in the construction plan, require specific discharge information and evidence of satisfactory formal training in waste management and odor control.

The EPA general permit does not require periodic reports from hog producers, but some states e.g. Oklahoma, require these during operation, together with records of operation. NPDES permits are generally issued for five-year periods, but state permit lengths do vary among states. The one year permits are more common, but in North Carolina, state permits are issued for time periods deemed reasonable by the Director of the Division of Environmental Management. There are permit application fees, generally ranging from $10 to $150. In Virginia, the applicant is only required to pay the cost of public notices.

To ensure compliance with permit requirements states also adopted fines for violating both general and state permits. Violations range from making false statements to willful disposal or negligence. Criminal negligence may lead to incarceration. Wastewater removal and land application of wastes are generally prohibited by many states under permit requirements. Wastewater may not be discharged into U.S waters at all. The rates for land application of wastes may not exceed crop requirements. Land application is generally prohibited when the ground is frozen, saturated, covered with ice or snow, or when significant precipitation is expected within 24 hours. Manure and ponds solid handling management plans should include lagoon location and storage and handling of wastes at the confinement facility.

Many states have enacted tax policies that broadly exempt agriculture from municipal and sales taxes. Hog operations may not be the primary reason for this, but they are a significant beneficiary. Agricultural districting and right-to-farm statutes in a broad sense protect livestock and other agricultural operations from nuisance suits. The states of Texas, Georgia, and Mississippi are among those which had no agricultural districting statutes.

There are regulations covering facility location in many states. In Oklahoma for instance, hog facilities may not be located within watersheds; should be located at least three miles from the outskirts of a municipality or one mile from ten or more occupied residences. In Kentucky no specific requirements exist, but the site must be approved by the Division of Water District Office. In almost all cases facility inspection by authorized personnel is carried out. It is shown in table 3 and table 4 that the differences in environmental regulations affecting the hog industry are not profound. What may vary greatly, though, is enforcement.

Data

Data for hog inventory, taxes, land values, land in farms, corn production, price of corn, and value of hog were obtained from the National Agricultural Statistical Services (NASS) of the USDA. In some cases we have had to deflate nominal monetary values by the U.S. Consumer Price Index with 1990 as base year, over the period under review, to obtain real monetary values. The Green Index was obtained from Hall and Kerr (Green Index: A State-by-State Guide to the National Environmental Health), and state unemployment figures from the U.S. Bureau of Labor Statistics. Other production statistics used in this study were obtained from the USDA. Data for the state of Oklahoma was excluded from the econometric analysis because during the period under review (1988-1992), Oklahoma was not a major hog producing state. The USDA database did not include data on size distribution of the Oklahoma hog industry.

Table 3. Matrix of Environmental Regulations in the US Hog Industry (OK, AR, TX, GA, KY)

STATE	OKLAHOMA	ARKANSAS	TEXAS	GEORGIA	KENTUCKY
State agency responsible for regulating the environment	The Department of Environmental Quality	The Department of Pollution Control and Ecology and its oversight body, The Arkansas Pollution Control and Eco-logy Commission	The Texas Natural Resource Conservation Commission	The Environmental Protection Division of the Department of Natural Re-sources; The Natural Resources Conservation Service; The Georgia Soil and Water Conservation Commission	The Natural Resource and Environmental Protection Cabinet
Under direct EPA jurisdiction1	Yes	No	Yes	No	No
Permit Approval	General and state permit	State permit; waste management; water use registration	General and state permit	State permit; operation permit; water quality permit; water use permit; all operations exceeding NPDES requirements must obtain Land Application System (LAS) Permit	Construction permit; operation permit (No discharge and discharge permits)
Size requirement	750 hogs; 300 cattle	750 hogs; 300 cattle	750 hogs; 300 cattle	750 hogs; 300 cattle; more than 1000 animal units for LAS permit	No minimum for no discharge permits; 750 swine for discharge
Pollution prevention plan	Required as part of application process	Evidence of satisfactory formal training in waste management and odor control required	Required	Waste control systems; specific discharge information	Design criteria for waste sites included in construction permit
Record keeping	Required during operation		Required		
Periodic reports	Required during operation		Not required under EPA general permit		
Environmental assessment	Required before approval		Required before approval		
Permit length	General permit - 5 yrs; State permit - 1 yr.		General permit – 5 yrs.	5 years	

1 The EPA delegates authority to some states to enforce EPA regulations, and retains authority to do so in about 12 states.

Table 3. Matrix of Environmental Regulations in the US Hog Industry (OK, AR, TX, GA, KY) (continued)

STATE	OKLAHOMA	ARKANSAS	TEXAS	GEORGIA	KENTUCKY
Application fees	$10-$150, depending on size, for state permit		$150 for state permit		
Fines for violations					
A. General permit					
1. False statement	Max. $10,000		Max. $10,000	$10,000 - $20,000/day and a criminal jail term of 2-4 years	Up to $25,000 per day
2. Willful violations	$2,500 - $25,000/day		$2,500 - $25,000/day		
B. State permit					
1. False statement	Max.. $5,000			$2,500/day for individuals to $1,000,000 for organizations	
2. Willful violations	Max. $100			$2,500/day for individuals to $1,000,000 for organizations	
3. Negligence	$200 - $1,000 / violation				
Wastewater removal	Prohibited if discharged into US waters				
Land application of waste	No land application of wastes when ground is frozen or during rainfall. Must be based on N-content of wastes and crop requirement	Prohibited when soil is frozen, saturated, covered with ice or snow, or when significant precipitation is expected with 24 hours	Wastes may not be applied to land that is subject to flooding, frozen, or snow covered, adjacent to water-bodies or steeply sloping	Wastes may not be applied to frozen ground or snow; immediately after rainfall or within 12 hrs of forecasted rain; liquid application rate should not exceed _ inch per hour	
Manure and pond solids handling	Storage and land application may not cause discharge or violation of water quality	Management plan for storage and handling of animal waste at confinement facility, and site management plan for each land application site		Lagoons should be located a minimum of 300 ft from neighboring dwellings, and should be cleaned out when 70% of its volume is occupied by solid wastes or sludge	

Table 3. Matrix of Environmental Regulations in the US Hog Industry (OK, AR, TX, GA, KY) (continued)

STATE	OKLAHOMA	ARKANSAS	TEXAS	GEORGIA	KENTUCKY
Regulations on reduction storage and utilization of wastes	Terracing; retention of animal wastes on premises; treating rainwater falling on waste as wastewater				
Preferential agricultural taxation	Yes, agriculture is broadly exempt from municipal and sales taxes	Yes	Yes	Yes	Yes
Agricultural districting2	No	Yes	No	No	Applicable at local level
Facility location	Facility may not be located within water-sheds; should be located at least 3 miles from outskirts of municipality or 1 mile from the or more occupied residences	Facility may not be located within 1,320 ft. of nearest occupied dwelling. Buffer of 500 ft. applies to all other structures	Facility may not be located in the Edwards aquifer recharge zone; no prohibited location requirements within the general permit language	Minimum buffer zone of 150 ft. from treatment/ storage lagoons to neighboring property lines, 300 ft. from edge of wetted field to any habitable structure not belonging to operator	No specific requirements exist, but site must be approved by the Division of Water District Office
Inspection of facility	EPA Director or duly authorized personnel may inspect facility and records		EPA Director or duly authorized personnel may inspect facility and records	Commissioner of Agriculture or duly authorized personnel may inspect any facility at any time	Yes
Right-to-farm statute3	Yes	Yes	Yes	Yes	Yes

Source: National Center for Agricultural Law Research and Information, University of Arkansas School of Law.

2 Agricultural areas created by law to protect farming operations in these districts from nuisance actions. Could be used to protect farmland from conversion to non-farm uses.

3 Legislation enacted to protect agricultural operations from nuisance suits when they have been in operation for sometime and are deemed to be in compliance with state regulations.

Table 4. Matrix of Environmental Regulation in the Hog Industry (NC, MS, PA, VA, MO)

STATE	NORTH CAROLINA	MISSISSIPPI	PENNSYLVANIA	VIRGINIA	MISSOURI
State agency responsible for regulating the environment	The North Carolina Department of Environment, Health and Natural Resources	The Department of Environmental Quality	The Department of Environmental Resources; the Environmental Quality Board	The Department of Environmental Quality	The Department of Natural Resources
Under direct EPA jurisdiction[4]	No	No	No	No	No
Permit approval	No permits required for most producers, but registration is essential; operation with <100 animal units are deemed permitted and should only follow best management practices	NPDES permit; state wastewater treatment permit; water use permit	NPDES permit; state permits for manure management; Agricultural operations are permitted only if manure management requirements are not followed	State permit for discharge (VPDES) and no discharge (VPA); General Virginia Pollution Abatement Permit; water usage permits required for certain thresholds	NPDES permit; construction permit; operation permit
Size requirement	250 hogs; 100 cattle	750 hogs; 300 cattle	2500 hogs; 1000 cattle	750 hogs; 300 cattle	2500 hogs; 1000 cattle
Pollution prevention plan	Animal waste management plan must be certified				
Record keeping					
Periodic reports					
Environmental assessment					
Permit length	Period of time deemed reasonable by Director of Division of Environmental Management (DEM)	5 years	5 years for NPDES permit	5 years	1 – 5 years

4 The EPA delegates authority to some states to enforce EPA regulations, and retains authority to do so in about 12 states.

Table 4. Matrix of Environmental Regulation in the Hog Industry (NC, MS, PA, VA, MO) (continued)

STATE	NORTH CAROLINA	MISSISSIPPI	PENNSYLVANIA	VIRGINIA	MISSOURI
Application fees	DEM assesses fees, but may not be higher than $7500		$500	Applicant pays for public notice	Dept of Natural Resources provides information on fees
A. General permit					
1. False statement					
2. Willful violations					
B. STATE PERMIT					
1. False statement		Up to $10,000			
2. Willful violations	Up to $10,000 per day for water quality violation; up to $5,000 for first offense in willful discharge of pollutants	Up to $25,000 per violation	Civil remedies of $500 for first day of violation and $100 for each additional day	$25,000 per violation; willful violations are felonies and fines range from $2,500 to $50,000 and imprisonment	Fines range from $2,500 to $50,000, and jail term for willful violations; $100 - $500 for polluting without a permit
3. Negligence					
Wastewater removal					
Land application of waste	Must be approved in advance by DEM after submitting requisite information	Wastes may be applied at least 50 ft and 300 ft from nearest adjoining property line and occupied dwelling respectively	Waste may not be applied to: frozen or snow covered land; land susceptible to flooding; within 100 ft of waterbodies; slopes adjacent to waterbodies	Holders of VPA permits may apply wastes to land under permit conditions; no statutory requirements for level of nutrients required	
Manure and pond solids handling					
Regulations on reduction, storage and utilization of waste		Requirements for proper waste management incorporated into NPDES permit	Manure management plan for livestock operations required		Regulations specifically describe requirements and recommendations for waste handling structures

Table 4. Matrix of Environmental Regulation in the Hog Industry (NC, MS, PA, VA, MO) (continued)

STATE	NORTH CAROLINA	MISSISSIPPI	PENNSYLVANIA	VIRGINIA	MISSOURI
Preferential agricultural taxation	Yes	Yes	Yes	Yes	Yes
Agricultural districting5	Yes	No	Yes	Yes	Yes
Facility location	No less than 100 ft between waste facility and state surface water	At least 1000 ft from nearest occupied dwelling and 300 ft from adjoining property line	Operators should check local zoning requirements	At least 25 ft from improved roadways; 200 ft from occupied dwellings; 100 ft from water supply wells; 50 ft from waterbodies; 25 ft from property lines	At least 50 ft from dwelling; 100 ft from water supply structure
Inspection of facility		Commission is authorized to inspect private property at reasonable times	The Department of Agriculture has the right to enter any premises		The Depart of Natural Resources is authorized to inspect facility
Right-to-farm statue6	Yes	Yes	Yes	Yes	Yes

Source: National Center for Agricultural Law Research and Information, University of Arkansas School of Law.

5 Agricultural areas created by law to protect farming operation in these districts from nuisance actions. Could be used to protect farmland from conversion to non-farm uses.

6 :Legislation enacted to protect agricultural operations from nuisance suits when they have been in operation for sometime and are deemed to be in compliance with state regulations.

Research Methods

The study uses pooled cross-sectional and time series data to estimate the relationship between the dependent variables measuring growth in the hog industry, and the independent variables. The approach assumes a random intercept to give an error components (or variance components) model that can be estimated by generalized least squares. The influence of multiplicative heteroscedasticity makes the ordinary least squares estimator biased and inefficient, although it is best linear unbiased for the dummy variable estimator. The method proceeds by appropriately transforming the observations and then applying ordinary least squares to the transformed observations. This method is particularly appropriate where there are more cross-sectional than time series data (Greene, Judge *et al.*).

The method outlined by Judge *et al.*, and available in the SHAZAM Econometrics Computer Program manual (pp.250-253), assumes the following general model:

$$y_{it} = \beta_{1i} + \sum_{k=2}^{K} \beta_k x_{kit} + e_{it}, \tag{5}$$

where i=1,2,...,N; and t=1,2,...,T. It is assumed that β_{1i} are independent random variables with mean β_1^* and variance σ_μ^2. They represent the intercept coefficient for the ith cross-sectional unit , while the β_k represent the slope coefficient common to all cross-sections. The dependent variable is y_{it}, the x_{kit} are the explanatory variables and the e_{it} are independent and identically distributed random variables with $E[e_{it}] = 0$ and

$E[e_{it}^2] = \sigma_e^2$. Sometimes known as the dummy variable estimator equation 5 may be rewritten as:

$$(6) \qquad y_{it} = \sum_{j=1}^{N} \beta_{1j} D_{jt} + \sum_{k=2}^{K} \beta_k x_{kit} + e_{it}.$$

The D_{jt} are known as dummy variables and can take values of 0 or 1.

Given that the N individuals constitute a random sample from some larger population whose parameters we wish to learn more about we can express β_{1i} in equation 5 as:

$$(7) \qquad \beta_{1i} = \beta_1^* + \mu_i,$$

where E[μ_i]=0; E[μ_i^2]=σ_μ^2, and [$\mu_i \mu_j$]=0 for $i \neq j$. We would also assume that μ_i are not correlated with the e_{jt}. Thus equation 5 becomes:

$$(8) \qquad y_{it} = \beta_1^* + \sum_{k=2}^{K} \beta_k x_{kit} + \mu_i + e_{it}.$$

This is the error components model. It is assumed that the correlation is constant over time and identical for all individuals. This model provides an unbiased estimator for the variance σ_μ^2.

To test the hypothesis that the individual components do not exist, that is $\mu_i = 0$, or $\sigma_\mu^2 = 0$, which makes the least squares estimator best linear unbiased, the Lagrange multiplier statistic (Breusch-Pagan) may be used.

The entire procedure is summarized below as given in Judge *et al, (*pp.479-490).

1. Estimate the dummy variable estimator.
2. Use residuals from the procedure above to calculate the disturbance variance.

3. Observations in the individual means are used to calculate the least squares estimator.

4. Residuals from step 3 are used together with the disturbance variance to calculate the variance of the random components.

5. The observations are transformed.

6. Estimate the estimated generalized least squares estimator using the transformed observations.

Model Specifications

The impact of environmental regulations on the size of hog operations is evaluated by the model below:

$$\begin{aligned} FSIZE_{it} &= \beta_1 + \beta_2 TAXES_{it} + \beta_3 PROD_{it} + \beta_4 CPRICE_{it} + \beta_5 GINDEX_{t} \\ &+ \beta_6 LIFARMS_{it} + \beta_7 LVALUE_{it} + \beta_8 HVALUE_{it} + \beta_9 URATE + e_{it}. \end{aligned} \tag{9}$$

In this model we regressed number of large hog operations (FSIZE) against farm real estate taxes (TAXES), corn production (PROD), price of corn (CPRICE), Green Index (GINDEX) land in farms (LIFARMS) land value (LVALUE), Hog value(HVALUE) and unemployment rate (URATE). It is expected that the number of large hog operations which for this study has been defined as all operations with no less than 1000 hogs, will vary inversely as farm real estate taxes, and the price of corn. The effect of the Green Index is expected to be positive because, unregulated, hog operations will expand as far as economies of scale permit. Stringent regulation will decrease profitability as well as the incentive to expand. Corn prices are input costs and higher input costs will only hinder growth and expansion. Corn is a major input in hog production. It is therefore expected that hog operations will thrive in those areas where corn is readily available, in spite of the possibility the cost of transporting feed to the farms might be very low.

One of the best known product-factor ratios often used in agriculture as an explanatory variable is the Hog-Corn price ratio. This ratio has become less reliable as a predictor of changes in hog production in recent years. This is probably due to the high proportion of the total supply now originating on specialized farms, that are less inclined to vary production from year to year. The cost of feed, represented by the price of corn now makes up a smaller proportion of total costs (Tomek and Robinson). A more appropriate model would include corn price and hog price as explanatory variables, instead of the hog-corn ratio.

Unemployment rate is a proxy measure for availability of labor. A high unemployment rate in any area could imply available labor. This effect is expected to be positive.

The Herfindahl-Hirschmann Index is a measure of entropy and a key explanatory variable in market power studies (Golan, Judge and Perloff). It may explain the degree by which industries dominate the economy, but more so, the degree by which firms dominate the industry. United States government antitrust agencies have used such measures to mandate the breaking up of virtual monopolies in many industries. Market concentration is one measure which determines productivity in industries; its effect on structure and performance in the hog industry for instance may indicate how government policies impact the industry.

The U.S. Department of Agriculture data sets have five size groups (four in earlier years) into which hog operations in each state are categorized: 1-99 head, 100-499 head, 500-999 head, 1000-1999 head and 2000+ head. For *i* firms in the industry, the Herfindahl-Hirschmann Index is calculated as:

$$(10)\ HHI = (MS_1 **2,)*h_1 + (MS_2 **2)*h_2 + (MS_3 **2)*h_3 + (MS_4 **2)*h_4,$$

where the MS_n are each firm's market share in the state's hog industry for the 1-99 head category, 100-499 head category, 500-999 head category and 1000+ head category respectively. The h_m are the total number of firms per state per year for each of the four categories listed above. In calculating the index of concentration by this procedure it is assumed that firms in each category within each state are the same. They may however differ across states. The Herfindahl-Hirschmann Index ranges between 0 and 1, but is always positive. The market shares sum up to one. The interpretation of the effects of explanatory variables taken from the side of the producer, may be at variant with society's and ultimately the policy makers welfare. For instance lower taxes, lower input prices, and low level of environmental regulation, or enforcement could result in increased concentration, but might also encourage new entrants into the industry, given the apparently low cost of entry. The market effect of new entrants is to reduce the market share of existing firms. The result of high concentration in many industries has in many cases supposedly resulted to high output prices because of the firms monopolistic nature.

The model below may be used to evaluate the role of environmental regulation in market concentration.

$$HHI_{it} = \beta_1 + \beta_2 TAXES_{it} + \beta_3 PROD_{it} + \beta_4 CPRICE_{it} + \beta_5 GINDEX_t$$

(11)

$$+ \beta_6 LIFARMS_{it} + \beta_7 LVALUE_{it} + \beta_8 HVALUE_{it} + \beta_9 URATE + e_{it}.$$

This model, using the same independent variables as in equation 9, has a measure of concentration as dependent variable. Therefore the Green Index is expected to change positively as the Herfindahl-Hirschmann Index. On the other hand increases in taxes, and prices of other inputs should discourage expansion and have the net effect of decreasing the firms market share. These would show negative signs. Increased corn production might imply the availability of more feed, when it is affordable. This variable is expected to have a positive effect, since any expansion of the hog industry would only result to an increase in the Herfindahl-Hirschmann Index. A rise in employment would only come about as a result of expansion.

The impact of environmental regulation on total hog inventory (THI) is estimated with the regression shown below:

$$THI_{it} = \beta_1 + \beta_2 TAXES_{it} + \beta_3 PROD_{it} + \beta_4 CPRICE_{it} + \beta_5 GINDEX_t$$

(12)

$$+ \beta_6 LIFARMS_{it} + \beta_7 LVALUE_{it} + \beta_8 HVALUE_{it} + \beta_9 URATE + e_{it}.$$

The third model has the log of hog inventory as dependent variable and the previous set of independent variables. The Green Index should be positive while taxes and corn prices will change inversely. Unemployment rate should be positive.

One disadvantage of the error components model is that it sometimes returns negative variances. Under such circumstances the model may not be considered estimated. This was the case anytime hog industry growth rate was used as a dependent variable.

CHAPTER IV

RESULTS

Overview

As mentioned in the previous chapter the estimated generalized least squares estimation procedure was used to estimate the error components model. The estimator should be best linear unbiased, and appropriate.

Location of Hog Operations

Model 1 estimates the impact of environmental regulations on the size of hog operations. This model might even explain the location of large hog operations. For this study a large hog operation has been described as any operation with at least 1000 hogs.

Descriptive statistics suggest that there is an annual average of 662 large farms over the period under review and for fifteen states. This would be a small proportion of the total number of hog operations according to the USDA data, even though they probably account for more than fifty percent of total hog inventory.

The table below suggests that in 1992 only 17 percent of U.S. hog operations had a housing capacity of at least 1000 head. These accounted for 50 percent of total hog inventory in 1992, up from 31 percent in 1982 and 38 percent in 1987 (U.S. Census of Agriculture). In 1992 these farms contributed 56 percent of the total hog and pig sales.

Table 5. Characteristics of Hog Farmers by Production Capacity, 1992

Item	Less than 500	500-999	1000-2499	2500 or more
Percent of farms	60	23	14	3
Percent of sales	23	21	31	25
Average acres	466	659	692	681

Source: USDA , Farm Costs and Returns Survey, 1992.

The total number of U.S. hog farms could continue to decline but the number of large hog operations might actually be on the increase, possibly reflecting the existence of economies of size in the hog industry. This is underscored by the higher number of pigs farrowed per litter for hog operations with 2000 head or more (8.775 in 1996) compared to smaller hog operations. An important trend in U.S. animal agriculture is the move from diversified farms to specialized farms. The ensuing specialization may now be reflected in the larger and more efficient hog operations that exist. The observed trends might also be because of producers' adoption of new technologies such as artificial insemination and other improved breeding programs.

USDA rankings suggest that in 1996 Iowa was the nation's top hog producing state; in fact it is the nation's all-time top hog producing state. North Carolina at the second position appears to be growing faster than the other states. However, a recently proposed moratorium on hog industry expansion in that state might be enough to cap production at present levels, or possibly even reduce growth in the near future. Although corn as an input has been linked to hog industry growth in several states in the past, rapid expansions in states like Oklahoma, Arkansas and North Carolina might suggest that this is no longer the case.

Table 6. States Share of Total Hog Inventory (percent)

1996 rank	State	1988	1992	1996
1	Iowa	25.24	25.60	27.21
2	North Carolina	4.87	7.73	16.56
3	Minnesota	8.46	8.08	8.63
4	Illinois	10.10	10.14	7.83
5	Indiana	7.75	7.82	6.68
6	Nebraska	7.48	7.90	6.41
7	Missouri	5.14	4.90	6.23
8	Ohio	3.98	3.01	2.67
9	Kansas	2.70	2.47	2.58
10	Oklahoma	0.43	0.41	2.35
11	South Dakota	3.26	3.14	2.14
12	Michigan	2.25	2.20	1.78
13	Pennsylvania	1.75	1.80	1.69
14	Arkansas	0.97	1.39	1.47
15	Wisconsin	2.30	2.08	1.42
16	Georgia	2.18	1.89	1.42
17	Colorado	0.40	0.70	1.12
18	Kentucky	1.97	1.49	1.11
19	Texas	1.01	0.88	0.89
20	Tennessee	1.80	1.03	0.71

Source: USDA Hogs and Pigs Reports.

The proportion of total hog inventory in states like Illinois, Indiana, and Nebraska appear to be on the decline, even though they still rank among the top ten hog producing states. This might translate into reduced total inventory, perhaps a direct result of citizens and political desire for a slowdown in hog industry growth, given the environmental consequences of unregulated expansion.

The table below is 1992 data which confirm that there were more hog operations in the U.S. corn belt (54 percent) than in all the other states combined.

Table 7. Characteristics of Hog Producers by Region, 1992

Item	Lake States	Corn Belt	Plains States	South Atlantic	South Central	All Regions
Percent of farms	14	54	17	10	6	100
Percent of sales	13	55	15	12	5	100
Average acres	418	492	935	449	398	548

Source: USDA, Farm Costs and Returns Survey, 1992.

The above may not be true for 1997. In fact Oklahoma, one of the fastest growing hog producing states, ranked only 25th in total hog inventory in 1992. In 1996 it was ranked 10th. This is a reflection of the fact that hog operations may now be profitably undertaken in states which did not traditionally grow a lot of corn, even though it is an important feed component in the hog industry.

The effect of taxes on the number of large hog operations is negative but not significant, as shown in table 8 below. The proxy variable is farm real estate tax per $100 value of farm real estate value. Mo and Abdalla found a significant relationship between property tax per acre of farmland on hog inventory growth rate. Had it been significant it would have suggested that higher taxes depress expansion of farms in the hog industry.

The effect of state environmental policy was positive as expected but not significant. A high Green Index implies low environmental quality. The amount of farmland and the level of unemployment, a proxy for available labor, did not significantly affect the number of large hog operations.

Table 8. Regression of Number of Large (>999 head) Hog Operations on Environmental Regulations

Explanatory Variable	Estimated Coefficient
Farm Real Estate Taxes	-20.57
	(76.20)
Corn Production	0.25 ***
	(0.05)
Corn Price	-98.69 *
	(54.52)
Green Index	0.09
	(0.13)
Land in Farms	4.71
	(6.16)
Land Values	0.34 *
	(0.18)
Hog Value	-2.17 **
	(0.98)
Unemployment Rate	5.12
	(12.95)
σ^2 for dummy Variable Estimator	6905.20
σ^2 for EGLS estimator	2586.80
σ^2 for random components	261024.70
R^2	0.45

Note: Single asterisk indicates significance at 10%; double asterisk indicates significance at 5%; triple asterisk indicates significance at 1%. Standard errors are in parenthesis.

It has been observed in previous studies that the "new large hog operations" are becoming more concentrated and operating on smaller acreage, since they no longer include crop production components to which livestock wastes are returned. The proxy variable for available labor is not significant. Even though the amount of available labor may serve to bring new businesses in an area, over a period of time, expanding farms would employ more labor and possibly reduce the level of unemployment, instead.

Land values were positive and significant. This implies that states with many large hog operations had high land values. Hog values, as proxies for hog prices were significant but negative. As input prices there would be size expansion of hog operations if they were lower. Higher hog prices would reduce expansion. The coefficient for corn prices is also negative and significant at 10 percent. Given that corn and hogs are two of the most important inputs in the hog industry this model confirms that a significant increase in the prices of inputs would have the expected negative effect on the number of large hog operations.

But what this model shows is that probably the most important determinant in the location of large hog operations is the quantity of corn produced. This variable was positive and highly significant. It has shown that large hog operations were mainly located in areas where corn production was high. Over this same period (1988-1992) USDA data also suggest that there are more hog operations in the U.S. corn belt than in all the other regions combined. This translates into higher total hog inventory in this region. Thus feed availability, as well as its costs would play an important role in where the large hog farms are located, perhaps more than the present level of the state environmental policies.

With a coefficient of determination of 0.45 the model itself only moderately explains changes in the hog industry as they relate to the number of large hog operations.

Size Distribution of Hog Operations

Model 2 evaluates the impact of environmental regulations on size distribution of hog operations. The measure of concentration used is the Herfindahl-Hirschmann Index

(HHI), as described by Golan *et al.* It was first calculated using USDA data sets on size distribution of hog operations. HHI is always positive but never greater than 1. For each industry under consideration the firms market shares sum up to one. As the number of small firms increases relative to the number of large firms the Herfindahl-Hirschmann Index will decrease. The index of concentration increases as the number of firms in the industry decreases for a given level of output. This, alternatively, implies that the market share for each of these firms simultaneously increases. USDA data suggest that most hog operations are still small. This study estimated that a typical hog operation in the 1-99 size category controlled only 1/100,000th of the total market share in the average hog producing state.

Table 9. Characteristics of Hog Producers, 1988-1992

Category	Average number of head (per state)	Average number. of firms (per state)	Average size of operation (per state)	Average market share (per state)
1-99 head	183420	6365	29	1/100000
100-499 head	984070	4144	238	1/10000
500-999 head	803960	1179	682	1/2500
1000+ head	1381100	662	2086	1/1000

Source: Calculated from USDA data; Average size of operation is measured in number of hogs per operation.

Table 9 again confirms that the number of large (1000 or more head) hog operations is small, but they contribute the highest inventory of hogs. The typical large firm controls only 0.1% of the hog industry in the average hog producing state; still considered too small to largely effect market changes by its own non competitive practices, or for antitrust intervention. These figures will differ for individual states.

Results from econometric analysis suggest that farm real estate taxes per $100 of farm real estate value was highly significant, but positive. The implication is that higher taxes had the effect of increasing concentration in the hog industry. Market consolidation may have occurred through mergers, buyouts, or the less competitive firms simply going out of business because of high operating costs reflected by high farm real estate taxes. High operating costs should have the effect of keeping new low budget operations or small firms out of the hog industry. If output level should remain constant, at least, the market shares of firms remaining in the industry will increase.

The quantity of corn produced was significant. The negative sign indicates that it changes inversely as market concentration. One probable explanation is that the availability of a very important feed component encourages new firms to enter the industry. However the price of corn, and the price of hogs were not significant factors in market concentration.

The level of unemployment is positive and significant. As proxy for available labor, there appears to be an increase in the concentration index as labor becomes readily available to undertake production operations. Since concentration means relatively large farm sizes, the use of labor is bound to increase even if production operations are not entirely labor intensive.

The variable measuring land value was not significant, but the amount of available farmland was negative and significant. Again, the inverse relationship suggests that as farmlands increase, the result is a decrease in the concentration index. The availability of farmland may be a sufficient factor in new firm entry into the hog industry.

Table 10. Regression of HHI on Environmental Regulations

Explanatory Variable	Estimated Coefficient
Farm Real Estate Taxes	0.018***
	(0.006)
Corn Production	-0.00002 *
	(0.00001)
Corn Price	-0.019
	(0.016)
Green Index	0.00002 ***
	(0.000004)
Land in Farms	-0.001 **
	(0.001)
Land Value	-0.00004
	(0.00003)
Hog Value	0.00006
	(0.0002)
Unemployment Rate	0.007**
	(0.003)
σ^2 for dummy Variable Estimator	0.0009
σ^2 for EGLS estimator	0.0002
σ^2 for random components	0.0005
R^2	0.62

Note: Single asterisk indicates significance at 10%; double asterisk indicates significance at 5%; triple asterisk indicates significance at 1%. Standard errors are in parenthesis.

The measure of state environmental policies, the Green Index, is positive and highly significant. Thus, a high Green Index changing directly as the measure of concentration implies that state environmental quality is lower as the concentration index increases and vice versa. Given that the concentration ratio is a measure of firm size, one may opine that average firm size will be higher in states with poor environmental policies or high Green Indices. The previous model did not have conclusive evidence on this assertion, although the Green Index was positive. The 1000 animal unit threshold is required for permitting under the National Pollutant Discharge Elimination Systems program. It is however true that most states which have NPDES permitting authority also have lower cut-off figures. The state of Kentucky, for instance, has no minimum requirements for issuing a no discharge permit.

The model moderately explains variation in size distribution of hog operations given a coefficient of determination of 0.62.

Total Hog Inventory

The third model evaluates the effect of state environmental policies on total hog inventory. To avoid scaling problems the natural log of total hog inventory was used as dependent variable.

Farm real estate taxes per $100 value of farm real estate, is not significant, though negative, as in one of the previous models. Also insignificant but positive are corn prices, land values, and unemployment rate. However in a study which used hog inventory growth rate as dependent variable, Mo and Abdalla found out that property tax per acre of farmland, and land value were significant. Land in farms was positive and significant. This suggests that there is higher total hog inventory in states which have higher amounts of available farmland. This might even be a reflection of the number of operations established in such states, leading to the high total inventory.

Hog prices are significant but negative. Whether one looks at it from the consumers or producers point of view, total hog inventory is higher in states which have lower hog prices, or lower in states with higher hog prices. The problem of high input costs in hog production comes into focus.

Table 11. Regression of Total Hog Inventory on Environmental Regulations

Explanatory Variable	Estimated Coefficient
Farm Real Estate Taxes	-0.107
	(0.092)
Corn Production	0.0002 ***
	(0.00007)
Corn Price	0.019
	(0.067)
Green Index	-0.0002 **
	(0.000099)
Land in Farms	0.039 ***
	(0.009)
Land Value	0.00014
	(0.00022)
Hog Value	-0.003 **
	(0.0012)
Unemployment Rate	0.019
	(0.019)
σ^2 for dummy Variable Estimator	0.0058
σ^2 for EGLS estimator	0.0042
σ^2 for random components	0.154
R^2	0.47

Note: Single asterisk indicates significance at 10%; double asterisk indicates significance at 5%; triple asterisk indicates significance at 1%. Standard errors are in parenthesis.

Corn production is again highly significant and positive. Hog inventory would be higher in areas that produce high amounts of corn and probably lower in other areas. This agrees with USDA data showing that there are more hog operations and more hog sales, therefore more total inventory in the U.S. corn belt. The measure of environmental regulation, or state environmental policies, is significant but negative. It implies higher total inventory in states with higher environmental quality. Mo and Abdalla describe this as counter-intuitive. Given that our measure of environmental regulations is non-changing over time it is impossible to determine its effect over any appreciable length of time. One explanation is that high total inventory may have led to more environmental regulations and more stringent enforcement.

The model only moderately explains variations in hog inventory given a coefficient of determination of 0.47.

CHAPTER V

SUMMARY AND CONCLUSIONS

Overview

Results as given in the previous chapter indicate the influence of some factors on growth in the U.S. hog industry. Many studies have been undertaken on the impact of environmental regulation on industries other than agriculture, apparently because of the relative ease with which productivity could be measured in those industries. It still remains a difficult task to quantify or even define measures of environmental regulation, especially in the livestock industry.

The U.S. Hog Industry

This study focused on a measure of state environmental policies, as the measure of environmental regulation. This measure which is known as the Green Index, is a comprehensive index of 256 environmental indicators not only restricted to measuring environmental quality in the livestock industry. This may have implications for explaining its effect on the hog industry.

The state environmental policy measure was not an important determinant of the number of large hog operations in each state. The cost of complying with the requirements of environmental regulations may be small in relation to other costs of production. But this measure of environmental regulation should be directly measurable and directly related to the livestock industry alone. This measure was however significant for total hog inventory and the measure of concentration. The results may have been counter-intuitive in the former case, but results from the latter case suggest that concentration is negatively influenced by environmental regulation, reflected by increasing Green Indices. Hog inventory may have been higher in states with higher environmental quality. What this study did not accomplish though is to determine the relationship between concentration and total hog inventory i.e. whether high concentration measures translated into high total inventory or not. A plausible explanation is that regulations would have been implemented and enforced as a direct result of environmental degradation from livestock activities. The proposed moratorium on the hog industry in North Carolina for instance, might be sufficient to keep its environmental quality in check, but that state's total inventory will remain high in the near future.

It was observed that farm real estate tax calculated per $100 of farm real estate value was not significant either in the case of large hog operations or total hog inventory. It however showed a positive and significant relationship to the concentration index. Its actual effect may have been to put small marginal firms out of business. USDA data suggest that average hog farmers are now operating on smaller acreage than before because they abandoned the crop production component of their integrated farms. Their spending on farm real estate would be increasing because of the requirements of the new environmental regulations. Possibly, taxes levied on these properties are small in relation to other production costs. Mo and Abdalla found that property tax per acre of farmland was significantly but negatively affecting the growth rate in hog inventory. This could be misleading if farm sizes are actually decreasing. Taxes are indeed a form of regulation.

One very important factor affecting the hog industry is the quantity of corn produced. Corn being a major ingredient in livestock feed, this study found it positively influenced both the size of total hog inventory and the number of large hog operations. Presumably a large number of large hog operations are located in the major corn producing states of the U.S.; these same states probably have the highest total hog inventories, because of the availability of a major input. The effect of corn production on concentration is significant but negative. States with little corn production have a few large hog operations. Either small operations tend to be unable to survive without much corn production, or these states can only support production of a small number of hogs, and these hogs are concentrated in a few firms because of scale economies

The quantity of farmland significantly influenced total hog inventory, but not the number of large farms. The total inventory may include different operations, each of which requires a parcel of land for operation. That the amount of farmland does not influence the number of large farms in a state is consistent with earlier observations that, even as per head expansions are enhanced, the hog operations are now located on smaller land parcels than in previous years. This is consistent with observations that the quantity of farmland significantly, but negatively, influenced concentration in the hog industry. Thus, as the quantity of available farmland increases, the market share of firms in the industry decreases. If we assume no changes in demand and supply a reduction in market share implies a reduction in firm size.

Unemployment rate was used as a proxy variable for available labor to undertake farm operations. It was only significant and directly related to the concentration index, implying that increases in market shares may be triggered by the amount of available labor. Its use as a measure for available labor over any period of time is questionable, because hog farms, whether they are expanding or new, would employ some of that labor, and reduce the rate of unemployment.

The hog-corn price ratio is not an effective measure of input costs (Tomek and Robinson). It has been replaced by the actual input costs: the prices of corn and hogs. Corn prices have significant effects on the number of large operations but not on the total hog inventory or the concentration ratio. Since producers can pass on production costs to consumers in the form of higher prices, the decision to operate can be least affected, except where such costs are prohibitive. The decision to expand may be different. According to the results this may be negatively influenced by the price of corn, and the price of hogs.

Land values were used by Mo and Abdalla as proxy for general economic factors. This variable performed consistently well in their analysis. In this study it positively influences the number of large farms, but not total hog inventory, or the concentration index, and agrees with their statement that "such measures reflected a benefit, such as securing capital for needed expansion".

Conclusion

One important determinant of hog industry activity is the amount of corn produced; it enables more firms to survive, thereby reducing concentration. It is also apparent that large as well as small hog operations are mainly found in corn producing areas. These are consistent with findings that total hog inventory changes directly as the amount of corn produced, even though more recent evidence suggests that total hog inventory might be increasing in non-traditional corn producing states like Oklahoma. The models also suggest that corn and hog prices are important in the hog industry, but their effect on concentration is not quite explicit. Higher input costs will negatively impact both total hog inventory and the total number of large farms. The effect on individual firms possibly translates into higher production costs, which will directly result to a reduction in firm size.

The effect of state environmental policies on hog operations is difficult to ascertain. First, it had no influence on the total number of large hog operations, although consistent with observations (Knutson, Outlaw, and Miller), that EPA dairy waste management regulations had no effect on large profitable dairy farms. Second, it showed mixed results on total hog inventory. Its effect was significant, but the relationship inverse, implying higher hog inventory in states with high environmental quality. If stringent environmental regulation is expected to reduce total hog inventory, stifle expansion in the hog industry and reduce the level of concentration in the industry, the Green Index would be positive. This index positively impacted the measure of concentration, lending credence to the probability that firm sizes might actually increase under lax environmental regulation. The review of some state environmental regulations suggests that there is very little difference in available regulations among states. Any differences in hog inventory, number of large hog operations, or the concentration ratio attributable to regulation would be due to differences in enforcement, not differences in laws. The case of the North Carolina hog industry is proof that negative public perception of hog operations are the catalyst for legislative action. Third, the measure is available only for a point in time. It would have been more appropriate to use a variable that measures regulation over time and space. Fourth, the measure is composite and includes non-agricultural indicators. This problem could be avoided by omitting all but those indicators that have direct relevance to livestock operations.

The Green Index as a measure of environmental regulation is probably inappropriate for this study. It incorporates public attitude and policy decisions, and may be imprecise when applied to this problem. An alternate measure more related to the hog industry should be used in future research. Measures like state spending on water pollution abatement may be useful. The more precise variable could provide better results. Future research should start by identifying such a variable. Models that can include state policy measures may be more appropriate in determining these effects. These policies might include measures of enforcement or stringency of regulations directly related to pollution by the hog industry.

Major hog producing states like Oklahoma should be even more careful in identifying appropriate measures of environmental regulations in the hog industry to be able to evaluate their effect on the hog industry. It is still a difficult task relating such measures as state spending on water pollution abatement, and environmental indices like the Green and Lester indices directly to environmental degradation by the hog industry. The problem of varying degrees of stringency of enforcing regulations among states, should make any measure more related to stringency, than the number of laws.

This study does not include pre-1988 changes, except perhaps some effects from periods closer to 1988; nor does it include changes that may have occurred after 1992. Further studies may cover such periods.

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