Agricultural Economics Report

Number 584 July, 1995

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1. Introduction

Agricultural industrialization is a term used to describe the seemingly relentless trend towards larger farm production units, a more concentrated food processing industry, and the use of vertical integration and direct marketing to move products through the food system. The general pace of industrialization in U.S. agriculture has accelerated in recent years, though the process remains uneven across industry sectors. For example, the broiler industry has been almost completely industrialized for thirty years but the grains sector still operates primarily through traditional commodity market channels, with little vertical integration or direct marketing (Drabenstott, 1994).

Current interest in agricultural industrialization has centered around the remarkable changes taking place in the pork sector. Since 1980, the number of farms producing hogs has declined 65 percent (Hurt, 1994). Farms leaving the industry are typically small, with less than 100 hogs in inventory, while new investment is primarily in large scale farrowing units with 1000-3400 sows. Not surprisingly, the average size of hog farms has increased dramatically. There have also been significant regional production shifts with Corn Belt states losing about 4 percent of U.S. market share since 1985 and North Carolina surging to become the second biggest hog producing state behind Iowa (Hurt, 1994).

Industrialization in the pork industry is being driven by rapid adoption of new production and marketing systems. The new production system involves *integrators* who run large scale farrowing units and work with *contractors* to grow and finish their hogs.[1] Integrators own the hogs (and the profits or losses derived from them) and typically provide feed, transportation,

[1] Integrators may own some of their own feeding units as well but typically concentrate on farrowing operations and contract feed a significant proportion of their total production.

medication and other technical services to contractors. For their part, contractors provide buildings, equipment, and labor, in return for a fee. The latest technologies for lowering costs and enhancing animal health are typically applied, which allows greater and greater concentrations of animals. These large scale industrialized hog farms first emerged in North Carolina but are spreading to states such as South Carolina, Arkansas, Oklahoma, Texas, Colorado, Missouri and Utah. They concentrate animal waste into smaller geographic areas than do smaller, more dispersed, farrow to finish operations scattered throughout the Corn Belt, and so environmental quality has become a major issue in policy debates surrounding this new production system (Ervin and Smith, 1994).

The new marketing system involves direct marketing through long-term contracts between integrators and packers. Direct marketing allows improved coordination and reduced risk so that a more consistent, high quality, pork product can be delivered reliably to consumers. Some of the very largest hog operations in North Carolina are vertically integrated through the breeding, feeding, and processing stages of pork production, thus providing a highly coordinated system.

The purpose of this report is to evaluate trends and issues in pork sector industrialization, paying particular attention to implications for Michigan. While Michigan does have some sizable hog farms, large scale intergrator-contracting systems have not yet had a significant impact in the state. Hog production in Michigan is typically a farrow to finish operation run by independent farmers who rely on conventional commodity market channels to market their product. Marketing innovations are occurring, such as the 10 year full supply contract negotiated between the Michigan Livestock Exchange and the Thornapple Valley packing plant in Detroit. However, direct marketing through long-term contracts negotiated directly between producers and packers is atypical. There are real concerns about the long-term viability of this system given the rapid industrialization taking place in pork production and marketing in other

parts of the country. This report will outline and discuss some of the key factors which will determine future industry structure and location.

The report has four main parts. The first part examines historical production and price trends for hogs in order to set the scene for the analysis which follows. Production trends are provided for three distinct regions to illustrate some of the regional production shifts which have been occurring. The second part of the report focuses on technology adoption and industry structure. Traditional farrow to finish operations are contrasted with the newer integrator-contracting systems in terms of technology, capital requirements, labor requirements, and cost of production. The third part looks at impacts of pork industry industrialization on environmental quality, and at some of the ways in which environmental regulations affect the industry. The fourth part examines the question of industry location. Why has industrialization had a greater impact outside the traditional hog-producing Corn Belt states and what does this mean for the future of the industry?

2. Production and Price Trends

Figure 1 shows aggregate U.S. hog production and the annual average hog-corn price ratio from 1955 through 1993.[2] These historical production and price trends suggest cycles of growth and contraction in response to changing economic conditions and circumstances.

- The initial period from 1955 through 1970 was one of relative stability with production rising gradually to a peak of 55 billion pounds in 1971, and a hog-corn price ratio fluctuating around 7.5.

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[2] Production data are farm marketings and farm slaughter, less in-shipments, plus or minus inventory changes, all measured in pounds. The relative hog-corn price ratio is used as a broad measure of industry profitability, even though it assumes corn and hog prices are equally important in measuring profitability and ignores the impact of protein meal prices and other costs.

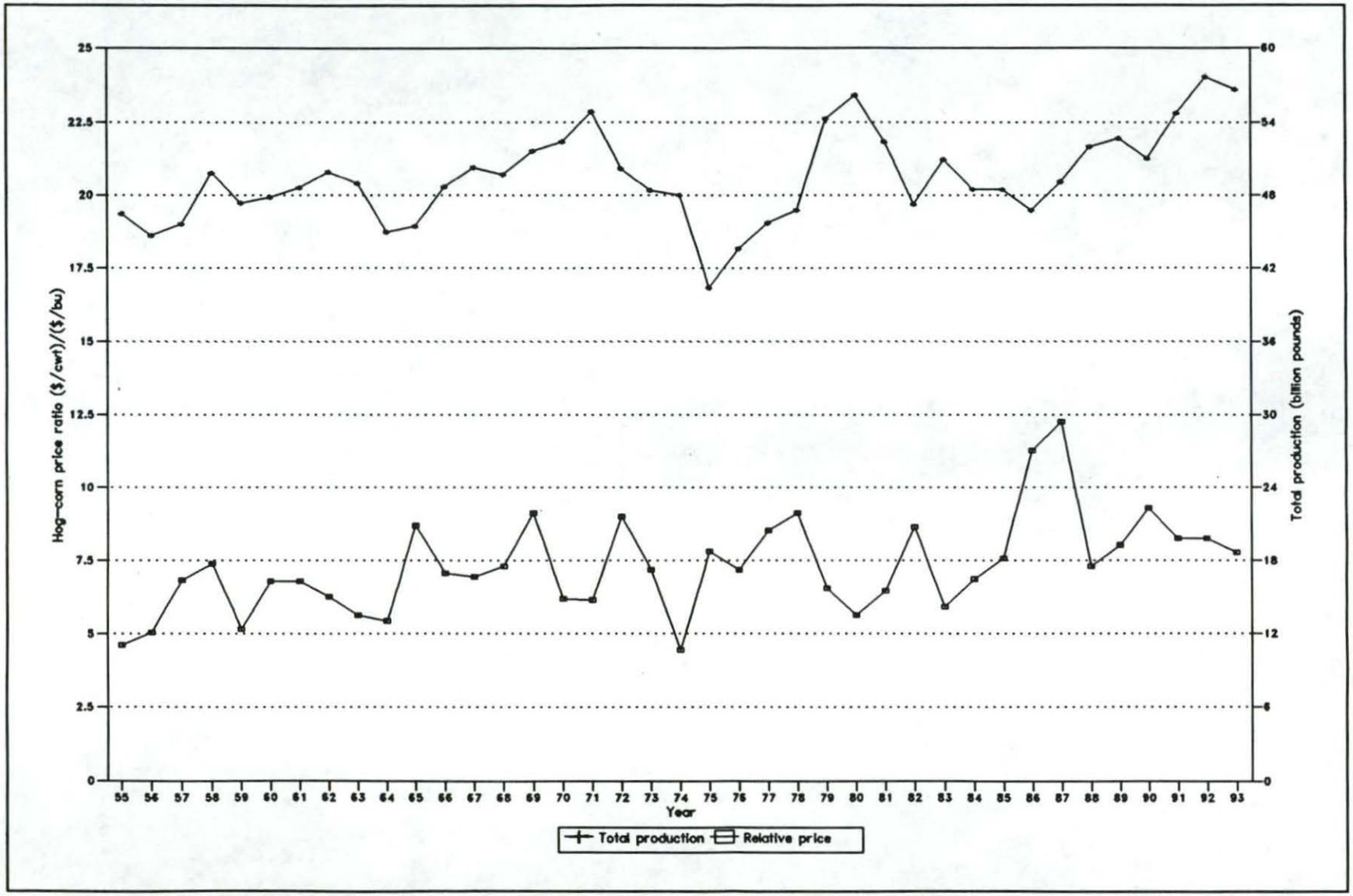

Figure 1 US Hog Production and Hog-Corn Price Ratios, 1955-1993

- The commodity crunch of the early 1970s led to a serious industry shake out. Production declined by almost 30 percent between 1971 and 1975 as feed prices increased and profitability shrank. By 1975 production had tumbled to 40 billion pounds, its lowest level over the entire four decade period.

- By 1975, profitability had begun to recover as corn prices eased and dwindling supplies of pork began driving hog prices higher. This resulted in a dramatic comeback in pork production from 1976 through 1980.

- The industry went through another difficult period beginning in 1979 and continuing into the early 1980s. A combination of plentiful supplies and weak demand led to falling profitability and a wave of exits from the industry.

- By 1983 the situation had stabilized and the industry entered a fairly prolonged period of growth and relative prosperity. Production has trended upwards throughout most of the period since 1983 and the hog-corn ratio has remained at relatively high levels.

Overall, the industry has experienced significant profitability and growth over time. Furthermore, the relatively high returns of the late 1980s and early 1990s encouraged new entrants and new investment, particularly when interest rates fell in the 1990s.

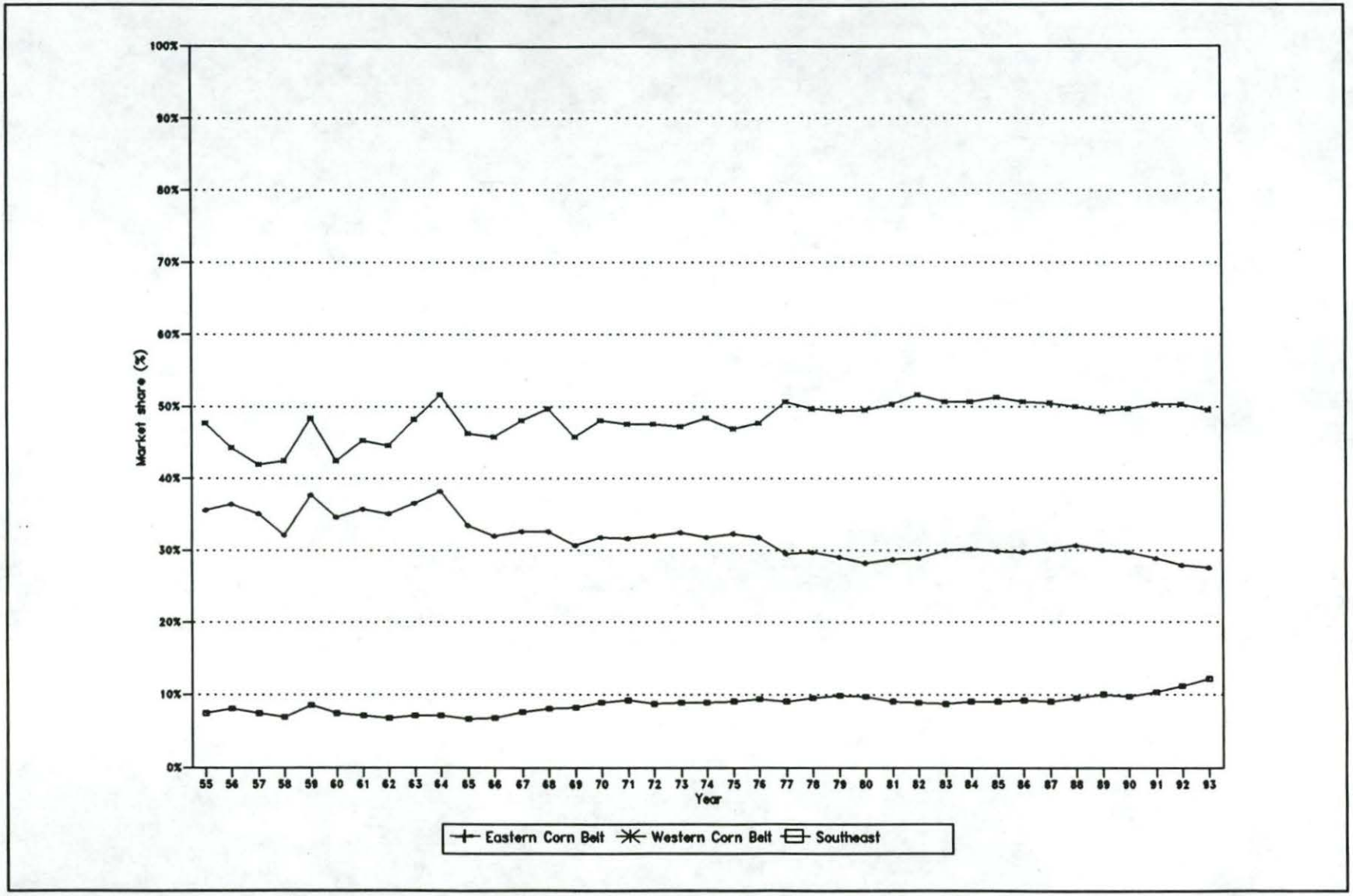

Figure 2 Market Shares of Hog Production in the Eastern Corn Belt, Western Corn Belt, and Southeast Regions, 1955-1993.

Aggregate production and price trends highlight industry-wide effects but mask regional production shifts which may have been taking place. Figure 2 shows market shares of three major producing regions—the Western Corn Belt, the Eastern Corn Belt, and the Southeast—over the same 1955 to 1993 period.[3] A number of trends are evident.

- The Western Corn Belt, which includes the largest hog producing state of Iowa, has maintained a fairly stable market share of around 50 percent over the past four decades. There have been some fluctuations in market share, particularly during the 1950s and early 1960s, and the data suggest a slight upward trend for this region over the entire period.

- However, the market share of the Western Corn Belt has dipped slightly over the last few years which may indicate the beginning of a downward trend associated with industrialization and the growth of integrator-contracting systems in the Southeast and elsewhere.

- The Eastern Corn Belt, which includes the major hog producing states of Illinois and Indiana, has a steadily declining market share over the period, with the decline accelerating in the last few years resulting in a market share well below 30%.

- The market share of the Southeast, which is dominated by North Carolina, has steadily increased with major gains occurring in the last few years. North Carolina is

[3] The Western Corn Belt consists of Iowa, Minnesota, Nebraska, Missouri, South Dakota, and Kansas; the Eastern Corn Belt includes Indiana, Illinois, Ohio, Pennsylvania, Kentucky, Michigan, and Wisconsin; and the Southeast consists of North Carolina, Georgia, Tennessee, and Texas.

now the second biggest hog producing state, behind Iowa, and production in the region is still growing rapidly.

While the Corn Belt still dominates hog production, it is increasingly clear that new technologies and production systems have made the industry much less dependent on the availability of cheap local feed. Other factors, such as labor costs and the proximity of major pork consumption regions, are becoming increasingly important. Thus, we have seen considerable growth in production from non-traditional hog producing areas and can probably expect to see more regional shifts in production in the years ahead.

The current industry outlook is for domestic pork demand to remain steady at around 70 lbs per capita on a carcass basis. Assuming population growth continues at low levels this suggests moderate increases in domestic demand (Lawrence, 1993). Export demand is more uncertain but there is potential for growth, particularly if prices remain low. The supply outlook is for continuing productivity increases and abundant pork supplies. The combined effect of these supply and demand side forces will be to continue putting downward pressure on hog prices and profitability over the next few years. The resulting downturn will have ramifications throughout the industry, but the full implications of this impending shake out are difficult to predict. One scenario is that industrialization will accelerate as returns to hog production decline because only the largest, most efficient, producers will be able to survive. On the other hand, many of these large industrialized hog farms have never experienced sustained periods of low returns and so their ability to survive such periods has never really been tested. There is also the possibility that industrialization will deepen and lengthen periods of industry recession because the sheer size of the investments involved gives firms less flexibility to reduce production or exit.

Production Trends in Michigan

Michigan is part of the Eastern Corn Belt and currently produces around 500 million pounds of hogs a year. Production in Michigan has been fairly stable over the years except for a significant jump in the early 1980s when production increased from the range of 200-250 million pounds a year to about 450-500 million pounds. During the same period, Michigan's market share jumped from around 1 percent of the industry total to about 2 percent. This jump appears to have resulted from new investments taking place in Michigan hog production as the industry began to recover from the industry recession of 1979-82.

So far, Michigan has shown little sign of the declining production levels and market share that have characterized some other Eastern Corn Belt states. Michigan exports corn and so has the advantage of an abundant supply of relatively cheap feed. Furthermore, the typical hog operation in Michigan is significantly larger than in some other Corn Belt states, which has undoubtedly kept costs of production low and provided Michigan with an advantage. The Thornapple Valley packing plant in Detroit processes more hogs than are currently being produced in Michigan, and so the state has ample processing capacity readily available. These factors, along with the adoption of efficient production practices, have helped to keep the state's hog producers competitive.

3. Technology Adoption and Industry Structure

The pork industry is technologically dynamic. Investments in improved genetics have led to a more productive system in which sows farrow more pigs more often, and hogs gain weight more rapidly. Genetic research has also led to a more uniform, high quality, low fat pork carcass. Technological improvements in feeding, health, housing, and processing of hogs have further contributed to increased productivity.

A common feature of many of these technological advances is that they generate *increasing returns to scale*. That is, while improvements raise productivity and lower costs for all producers, they tend to lower unit costs more for larger producers than smaller ones. This has contributed to a powerful trend towards expansion and growth for the most successful producers, and decline and departure for those least able to compete.

The evolving structure of the pork industry is illustrated in Figures 3a-3c which show the decline in hog farm numbers, and the increase in average hog farm size, for the U.S. as a whole and for the major hog producing states of Iowa and North Carolina. The data cover the period from 1977 to 1993. The precipitous decline in hog farm numbers has been caused primarily by a decline in the number of smaller farms with less than 100 head of inventory. The number of medium sized farms with 100-499 head has also been declining, but not as sharply as the number of smaller farms. On the other hand, the number of larger farms with greater than 500 head of inventory has actually increased over the period. These graphs clearly indicate a rapid increase in average farm size. It is interesting that both Iowa and North Carolina share the same basic trends in farm size, although both the decline in the number of smaller farms, and the increase in the number of larger farms, are sharper in North Carolina.

Hog farm numbers for Michigan are provided in Figure 4. Unfortunately, annual data on Michigan hog farm sizes are only available from 1988, but it is interesting that the decline in farm numbers for Michigan from 1988-1994 is much less severe than in Iowa and North Carolina, and for the U.S. as a whole. In fact, Michigan numbers have held steady in the 1990s with minimal change in the farm size distribution. This may be a result of Michigan's favorable position in terms of feed prices, efficient production practices, and access to packers and markets. Despite these factors, however, the pressures to expand scale and reduce hog farm numbers are being felt in Michigan as elsewhere, and more structural change is likely in the future.

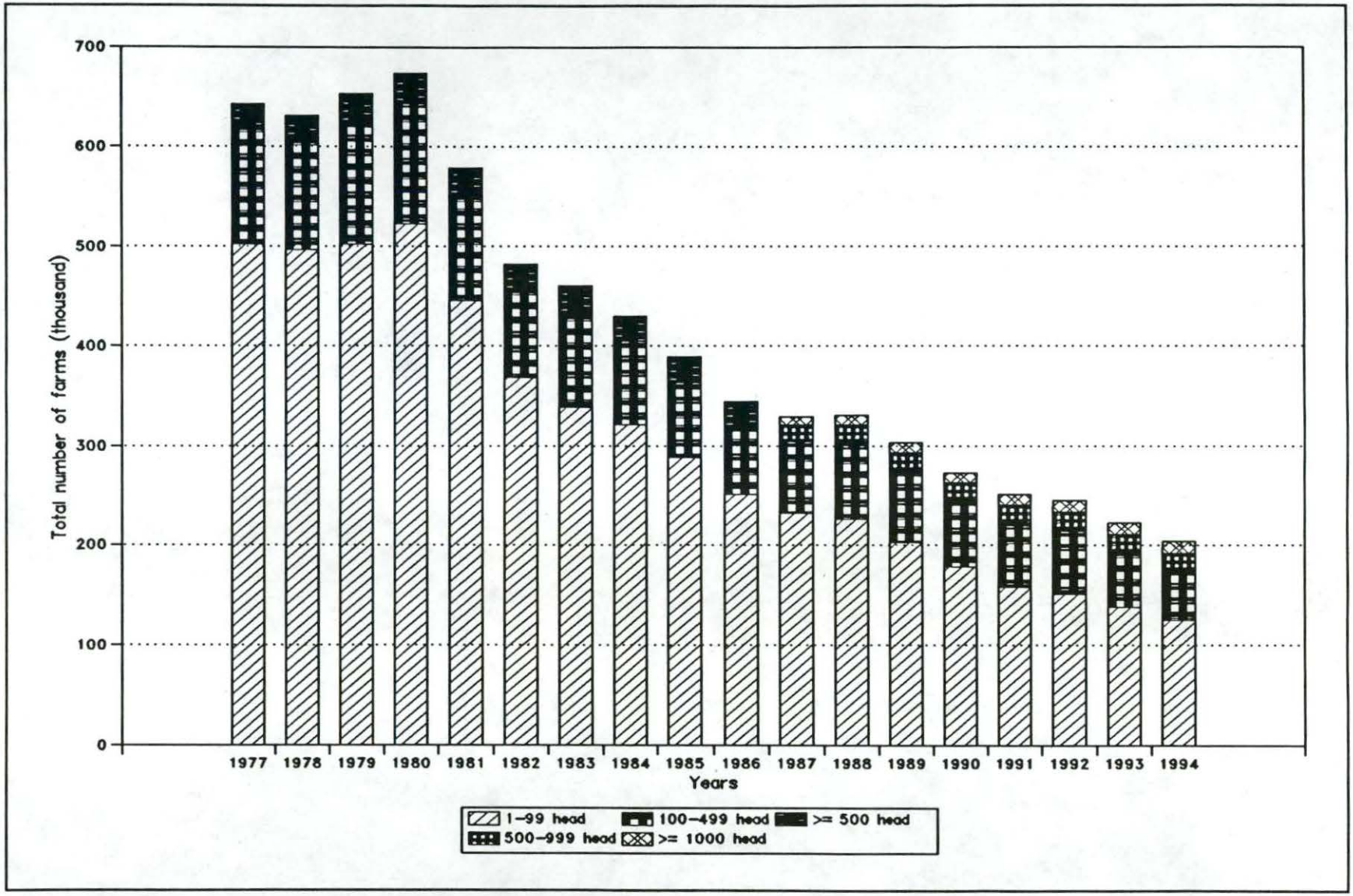

Figure 3a Number of Hog Farms by Size Category in the U.S., 1977-1994

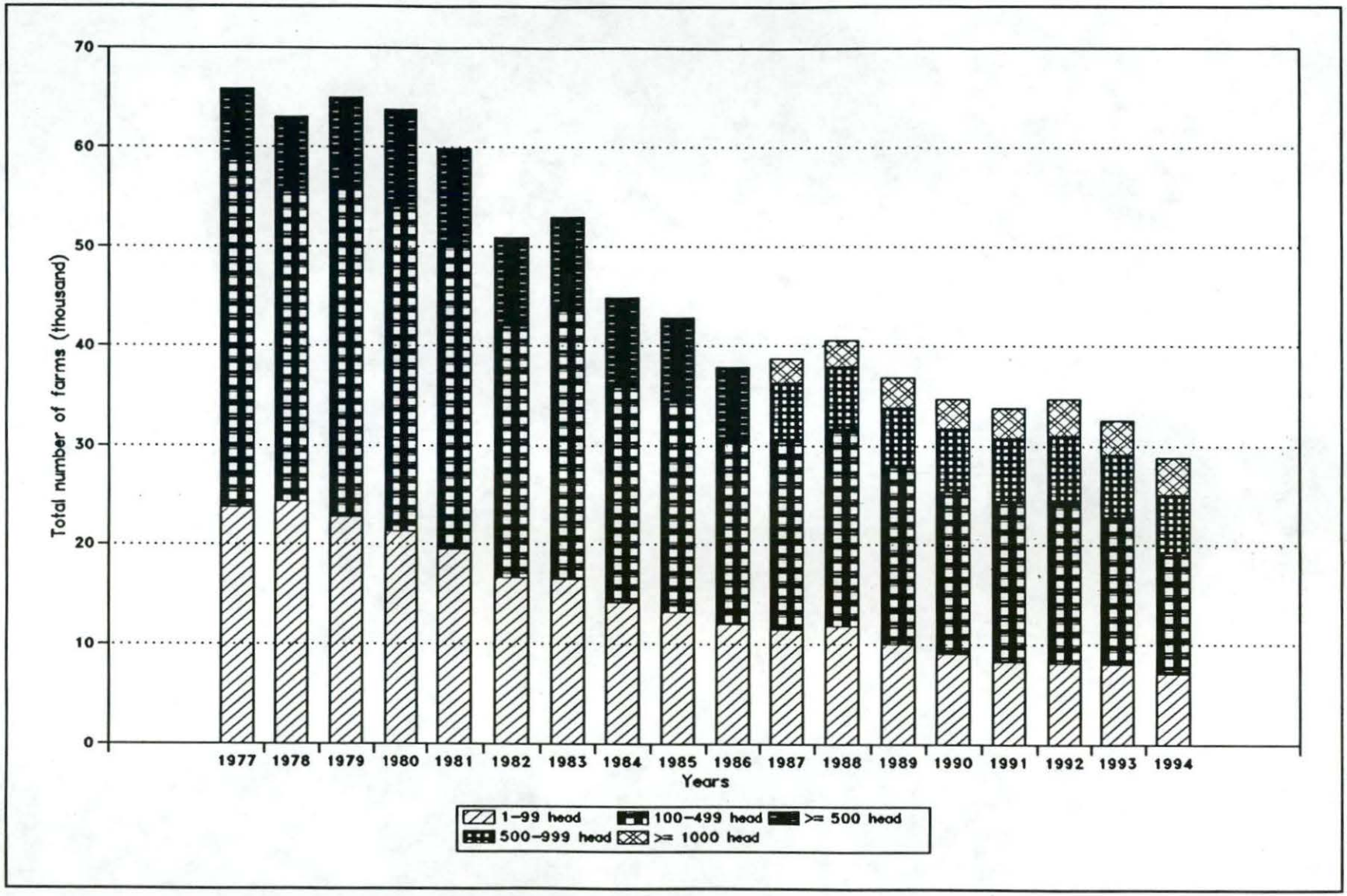

Figure 3b Number of Hog Farms by Size Category in Iowa, 1977-1994

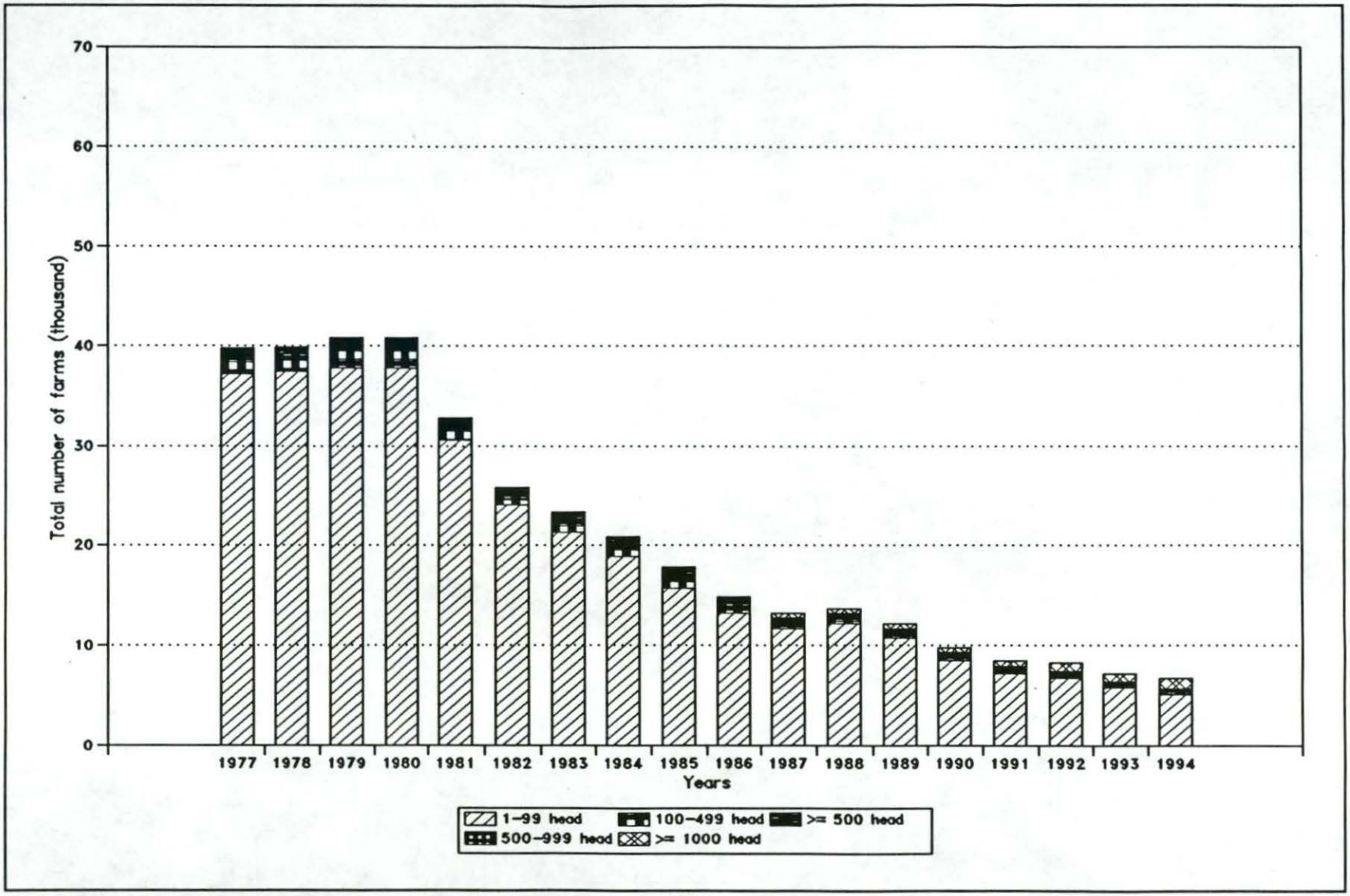

Figure 3c Number of Hog Farms by Size Category in North Carolina, 1977-1994

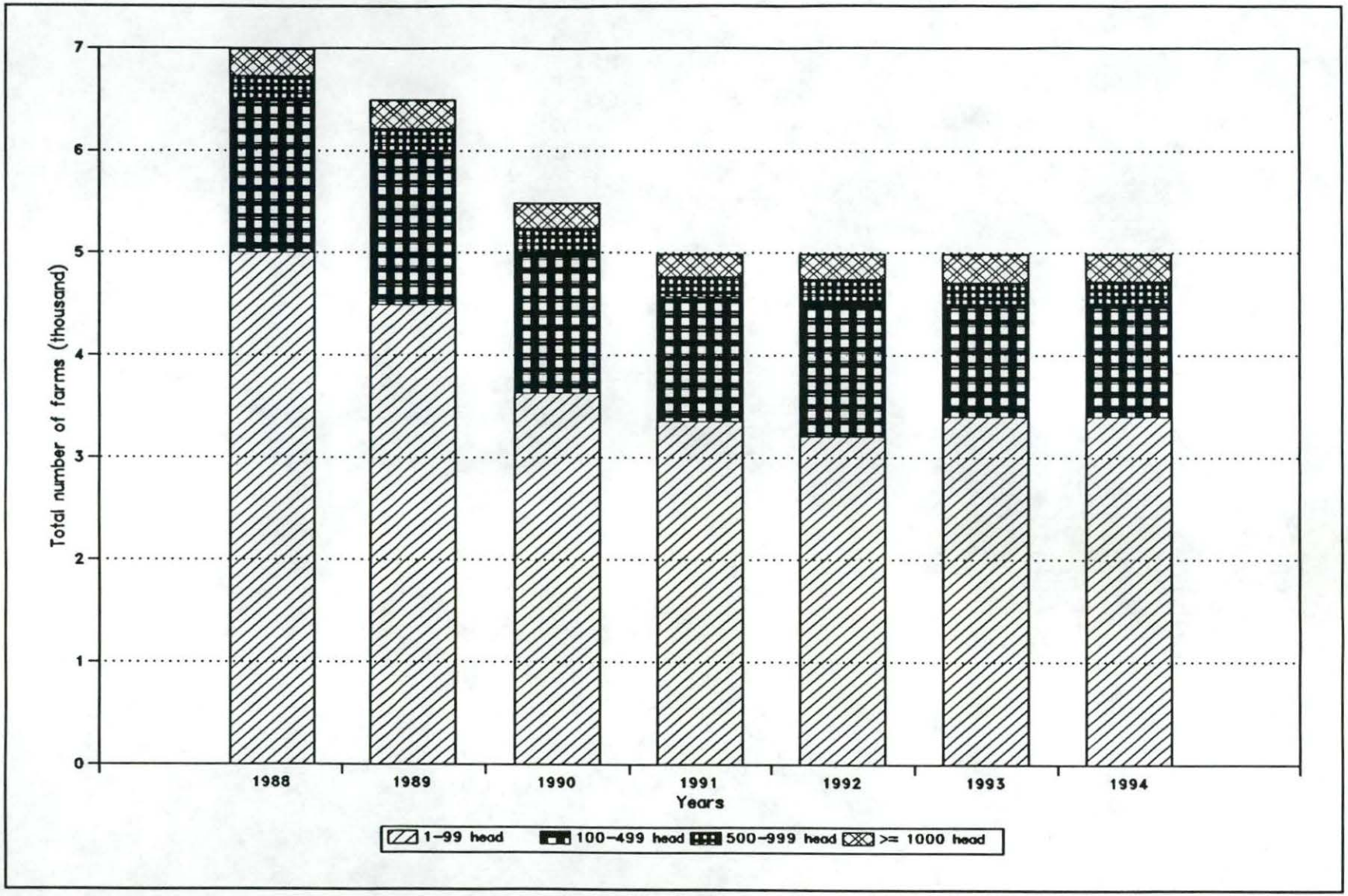

Figure 4 Number of Hog Farms by Size Category in Michigan, 1988-1994

Alternative Production and Marketing Systems

At the risk of oversimplifying, pork production might be characterized as having a *dualistic industry structure*. In the Corn Belt, the dominant production system remains the more traditional, smaller scale, farrow to finish operation. In the Southeast, and increasingly in other states outside major pork-producing regions of the Corn Belt, the integrator-contracting system dominates. While this dualistic characterization overlooks a considerable amount of variation in the size and type of production systems used in both the Corn Belt and other regions, it does capture an important feature of the industrialization process, and allows the two main production systems used in the industry to be compared and contrasted.

Table 1 compares two alternative production systems for hogs. The first is a traditional Corn Belt farrow to finish operation consisting of 100-250 sows. This is a fairly typical size for existing Corn Belt hog farms, although new investments would usually be in much larger operations. These farms farrow, grow and finish their own hogs in separate buildings and market them through conventional commodity market channels. They also grow most of their own feed. The alternative production system is an integrator-contracting operation running 1800-3400 sows per unit. New investments in this system are typically in 3400 sow units and integrators may own several such units in one or more locations.[4] This operation may feed some of its own hogs but the majority are contracted out to other operators who feed and manage the growing hogs in return for a fee.

Besides the very significant difference in the size of these operations, there are some important variations in technologies and the way finished hogs are marketed.

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[4] The largest of these operations, Murphy Farms located in North Carolina and Missouri, had a total of approximately 150,000 sows at the beginning of 1994.

Table 1. Comparison of Alternative Production and Marketing Systems for Hogs

Characteristic	Conventional Corn Belt Farrow-Finish Operation	Integrator-Contracting System
1. Size	100-250 sows[a]	1800-3200 sows[b]
2. Reproduction		
- Yield	18-20 pigs/sow/year	20-22 pigs/sow/year
- Artificial Insemination	Limited use.	Extensive use.
- Genetics	Variable.	Uniform, low-fat, high quality, high growth carcass.
- Weaning	Typically 6 weeks.	Early weaning at 2 weeks.
3. Labor		
- Family	Very important.	Less important.
- Hired	Limited use.	Specialized hired labor critical to operation.
4. Capital		
- Buildings	Smaller buildings including growing and finishing.	Larger buildings concentrating on farrowing (off-site growing and finishing).
- Investment	Relatively high capital investment/hog.	Relatively low capital investment/hog.
5. Feed		
- Finishing system	On-site growing and finishing with feed produced on farm.	Off-site growing and finishing via contract using purchased feed and centralized feed processing facility.
- Multiple site finishing	Limited use.	Extensive use.
- All in all out	Some use.	Extensive use.
- Split sex feeding	Generally not.	Extensive use.
- Pelleted high density phase feeding	Generally not.	Extensive use.
6. Waste Management		
- Intensity	Relatively low amounts of waste per unit area.	Relatively high amounts of waste per unit area.
- Technology	Held in storage pit then pumped and spread on local fields.	Storage and decomposition in lagoons then sprayed on local pastures and crops.
7. Marketing	Traditional commodity market channel to processors.	Long-term contract with processors and/or vertical integration.

[a] There is a wide size range among Corn Belt farms but 100-250 is fairly typical of current operations. However, new investment tends to be in much larger units of 1100 sows or more.

[b] The integrator-contracting operations range from 1800-3400 sows per building with new investment typically aimed at 3400 sows. Integrators may own multiple buildings in one or more locations.

- The integrator-contracting operations make extensive use of artificial insemination while the typical Corn Belt farm makes little use of this technology. Furthermore, the integrator-contractor uses a medicated early weaning system which allows increased productivity per sow per year, and invests in uniform, high quality, low fat genetics. While Corn Belt operations have also begun moving in this direction they currently do not make the intensive use of these technologies that integrator-contractors do.

- The Corn Belt operation is based primarily on general-purpose family labor and makes only limited use of hired labor. On the other hand, specialized hired labor is critical to the success of the large integrator-contracting operation, because of the size of the operation and the need for specialized functions and contract feeding.

- The Corn Belt farrow to finish operation requires more capital investment per hog marketed than the integrator-contractor. There are two reasons for this. First, it requires more investment to put up several buildings to house 3400 sows in small dispersed groups than to put up one large building, or group of buildings, to house them all in one location. Second, in the integrator-contracting system the integrator does not need to invest in buildings and equipment for the finishing operation because these are typically provided by contract.

- Corn Belt farrow to finish operations typically use hogs as a means of "marketing" their corn crop. They feed hogs with corn grown on the farm and have less incentive to engage in specialized feeding and rationing technologies. In the integrator-contracting system, feeding efficiency is critical. In this system, feeding typically occurs at multiple sites as hogs are shipped out under contract from the farrowing

operation. This results in large scale use of feed and has led to the development of efficiency-improving technologies such as *all-in-all-out*, where hog lots are kept together throughout the farrowing, finishing, and marketing process in order to prevent introduction of disease; *split sex feeding*, where gilts and barrows are separated and fed different rations; and *pelleted high-density phase feeding*, which is a technology for generating high efficiency feed conversion. While some of these technologies are starting to enter into the typical Corn Belt farrow to finish operation they are not yet widely used.

- The integrator-contracting system clearly concentrates animal waste because the animals themselves are concentrated into a smaller geographic area, rather than being more uniformly distributed. In the Corn Belt, manure is typically stored in a pit and spread over surrounding fields. In warmer climates, such as North Carolina, manure is typically stored and treated in a lagoon before being sprayed onto surrounding land which is often sown to coastal bermuda grass. The lagoon treatment reduces nitrate and phosphate content and the bermuda grass uses more nitrogen than corn. Hence, this system allows more waste to be spread on a smaller, more concentrated area of land.

- While Corn Belt operations typically market their hogs through traditional commodity market channels, integrators develop long-term contracts with packers. This allows for closer coordination of supply and demand by providing processors with a reliable supply of high quality product for their plants, and by providing integrators with a stable market for their product.

Cost of Production

How do costs of production compare under these alternative production systems? In a recent study at Purdue University, Good (1994) compared costs of production in three different sized Corn Belt operations with those from a typical large integrator-contractor located in North Carolina.[5] The Corn Belt operations are:

- a 250 sow single site, mixed sex, farrow to finish operation feeding corn grown on the farm with an on-farm feed program;

- a 650 sow single site operation using all-in-all-out production and split sex and phase feeding using corn grown on the farm; and

- a 3400 sow three site operation using corn grown on neighboring farms and using all of the modern large-scale technology, such as all-in-all-out production, split sex feeding, and phase feeding.

Costs of production in each of these systems were compared with a North Carolina operation characterized as:

- a 3400 sow, three site, operation using the same technology as the 3400 sow Corn Belt operation, except that corn is imported from Ohio, Michigan, and Indiana, and fed as pelleted high density feed, and the operation is integrated with a processor.

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[5] Thanks go to Chris Hurt and Keith Good for providing these data.

Each of the operations was assumed to be highly efficient, defined as being among the 30 percent of farms having the lowest costs among operations in their size and region. Costs were estimated for the 1992 production year and validated using a team of experts (see Good, 1994).

A summary of the cost comparisons are provided in Tables 2 and 3. Table 2 shows total and disaggregated costs under alternative production systems while Table 3 shows key differences between the Corn Belt operations and the North Carolina system. The Corn Belt operations have a clear advantage in feed costs and the smaller, single site, Corn Belt operations also have an advantage in lower pig hauling needs (and costs). In most other areas, however, the advantage goes to North Carolina. Labor, management, buildings, and equipment costs are all lower in North Carolina. It is interesting to note, however, that while these advantages allow the large North Carolina integrator-contractors to operate at lower cost than smaller Corn Belt farms, the feed cost advantage of the large 3400 sow Corn Belt operation more than compensates for the disadvantage in labor, capital, and management costs. Thus, a large 3400 sow Corn Belt operation using all of the latest technology has lower costs than a similar type of operation located in North Carolina.

These numbers suggest that the larger, more efficient, Corn Belt hog operations should be able to compete very effectively with the North Carolina integrator-contractor systems. It must be remembered, however, that there are many smaller Corn Belt farms with 250 sows or less. Furthermore, the cost data provided above are for the most efficient operations and therefore obscure a significant amount of variation in efficiency levels and production costs. Iowa State University swine enterprise records indicate a $10/cwt difference between cost of production for the one third of producers reporting the highest profit in 1993 and the one third reporting the lowest profit. Most farms in these records are farrow to finish, raise their own feed, and have an average inventory of about 100 sows. Clearly, it will become increasingly difficult for the smaller, less efficient producers to compete as the large scale integrator-contractors continue to

expand and prices fall towards long run marginal costs of production for the most efficient operators.

Table 2. Comparison of Hog Production Costs in the Corn Belt and North Carolina, 1992

Costs ($/cwt)	North Carolina	Corn Belt		
	3400 Sows	250 Sows	650 Sows	3400 Sows
Feed Costs	20.85	20.31	19.63	18.76
Direct Costs	4.54	4.71	4.04	4.44
Indirect Costs	10.00	13.90	12.82	11.24
Manure Credit	0.00	-0.21	-0.20	0.00
Contingency Costs	1.50	1.50	1.50	1.50
Total	36.89	40.22	37.80	35.94

Source: Good (1994). Numbers may not add due to rounding.

Table 3. Key Differences in Costs of Corn Belt Hog Operations Compared to North Carolina, 1992

Costs ($/cwt)	Corn Belt		
	250 Sows	650 Sows	3400 Sows
Feed Costs	-0.54	-1.22	-2.09
Hauling Pigs	-0.75	-1.00	0.00
Breeding Stock	+0.55	+0.49	-0.02
Equipment	+1.86	+1.22	+0.51
Buildings	+1.09	+0.71	+0.30
Labor/Management/Administration	+0.82	+0.87	+0.46
Total Cost	+3.33	+0.91	-0.95

Source: Good (1984). Total cost difference includes more than the sum of factors listed.

Costs of hog production in Michigan are kept low by an efficient production system. Michigan State University Telfarm records indicate average cost of production of $40.28/cwt in 1991 although, as in the case of the Iowa records, there is considerable variation around the average. Michigan has a clear cost advantage in feed but a disadvantage in terms of labor, management, buildings, and equipment costs. Overall, Good's (1994) analysis suggests that large efficient hog operations in Michigan can be quite cost competitive with the North Carolina integrator-contracting systems, but that smaller operations will come under increasing cost pressure.

4. Environmental Quality

There are several environmental concerns surrounding intensive livestock production in general, and the pork industry in particular.

- *Water quality* which is influenced by animal waste runoff from manure storage facilities and fields on which manure has been applied. The potential impact of hog production on water quality depends on the amount of waste produced, the type of storage and disposal system used, and the location and climate of the facility.

- *Air quality* which in the case of hog production means primarily odor problems. Hog production facilities generate odor which can be a significant nuisance to surrounding residents. The bigger the production facility, and the higher the site density in a region, the more likely an odor problem exists.

- *Soil quality* is affected by manure being spread on fields surrounding hog production facilities. Continued manure spreading over long periods can lead to nitrate and

phosphate build up in the soil which can eventually have toxic effects. The key issue here is the concentration of livestock production facilities in a given region since it can be expensive and inconvenient to transport manure over long distances.

- *Quality of Life* which is influenced by the health of residents, the aesthetic value of the environment in which individuals live, and the maintenance of property values. Production facilities attract fly and insect populations which may be detrimental to the health of farm operators, workers, and surrounding residents. Furthermore, as urban areas expand, and residential development occurs in formerly rural areas, conflicts between the needs of farmers in running their operations and the lifestyle aspirations of residents become increasingly common. Part of this issue relates to concerns about air and water quality but this is not the entire story. Being able to see livestock production facilities from homes, driving past them to get home, or even just knowing they are nearby, can be a source of contention.

Hog production practices are affected by several environmental statutes.[6] One of the most important is the *Clean Water Act*, a federal statute aimed at controlling pollution discharges into U.S. waterways. The act divides polluters into point sources, which are particular, discernable, means of producing and distributing pollutants, and nonpoint sources which essentially includes all other polluters. Point sources are regulated through the National Pollutant Discharge Elimination System (NPDES), a mandatory national permit system which controls point source pollution into U.S. waters. Intensive livestock operations, including hogs, may be classified as point sources of pollution depending on the size, amount of waste, location, slope, vegetation,

[6] Most of the following information on environmental statutes and regulations was obtained from Copeland and Hipp (1994a and 1994b).

rainfall, and the means by which waste products enter waterways. However, this would be the exception rather than the rule as most hog production facilities are classified as non-point sources of pollution. Nevertheless, this does not mean they can ignore the Clean Water Act. Under the Act, each state is required to develop a management plan to address point *and nonpoint* pollution problems and this management plan can have significant impacts on agricultural production practices.

The *Coastal Zone Management Act* requires each state containing a coastal zone to adopt a management program which identifies coastal zone boundaries, sets out permissible land and water uses within the boundaries, and identifies the management structure and means of control over the zone. The Act is designed to regulate nonpoint pollution sources and any agricultural activity, including hog production, which occurs within zone boundaries can be restricted by the management program for that zone. Great Lakes waters are included under the jurisdiction of this Act.

Three other pieces of federal legislation may affect intensive livestock facilities, although their impacts on hog production are generally minor. The first is the *Comprehensive Environmental Response, Compensation, and Liability Act* which allows the federal government to conduct cleanup operations financed by the "Superfund" and then seek to recover costs from potentially responsible parties. The second is the *Federal Insecticide, Fungicide, and Rodenticide Act* which is the major federal statute governing pesticide use. Finally, the *Clean Air Act* is one of the most comprehensive pieces of U.S. environmental legislation but has little impact on intensive livestock operations because it does not address the problem of odor. Typically, odor problems associated with hog operations are handled under state common law regarding nuisances.

Most hog operations are affected more by state and local laws than they are by federal statutes. The two main sources of liability for hog producers under state common law are

negligence and *nuisance*. Negligence occurs if the operator can be shown to be at fault for a breach of duty, or failure to conform to a standard, which causes injury to another person or their interests. Nuisance is an ambiguous term but has been defined as something which is offensive or noxious, and which interferes with the rights of others. Much of the successful litigation that has been brought against hog producers has been in the form of nuisance cases citing odor, destruction of the aesthetic environment, and associated reductions in property values. The most common form of local law is zoning regulations which specify where livestock can or cannot be housed within a local area, and possibly putting limits on the acceptable size of such operations.

The combined effect of these laws, regulations, and ordinances is to place hog producers under tremendous liability risk for pollution and environmental damage resulting from their operations. When a case is brought against a producer he or she is subject to possible injunctive relief (an order that the pollution be stopped). If the case against the polluter is successful there will be an assessment for cleanup costs as well as possible monetary compensation for bodily injuries and property damage.[7] Most statutes also provide for the recovery of other costs, such as investigation expenses, feasibility studies, attorney fees, and expert witness fees. Polluters may also receive civil fines of as much as $75,000 per day for continuing offenses. In cases where the polluter can be shown to have knowingly committed an act which violates a statute then criminal penalties, including fines and prison time, may be applicable. Furthermore, incorporation will not necessarily protect personal financial assets from environmental lawsuits. The courts have developed a number of legal doctrines to permit individual corporate officers and directors to be held personally liable for environmental damage (Copeland and Hipp 1994a, p.24).

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[7] The courts have been extremely generous regarding what constitutes "bodily injury," including not only physical injury but also pain and suffering, emotional distress, and the value of happiness and quality of life (Copeland and Hipp, 1994a).

Right-to-farm laws have been a traditional defense against nuisance lawsuits brought against farmers. These laws exempt agricultural operations from many of the usual forms of nuisance, on grounds that generally acceptable agricultural practices should be allowed in any suitably zoned area. It is becoming increasingly clear, however, that any protection offered by these laws is limited. Right-to-farm laws do protect farmers from certain kinds of nuisance suits, particularly when it can be shown that the "nuisance" existed prior to the plaintiffs arrival or planned development. However, the courts have also held that right-to-farm laws do not always apply when the "nuisance" involves a substantial change to an existing farm operation (Copeland and Hipp, 1994a p.23). Furthermore, right-to-farm laws offer no protection against environmental lawsuits other than nuisance suits, such as those based on federal statutes.

Michigan Environmental Regulations

In Michigan, the Department of Natural Resources (DNR) has primary responsibility for regulating environmental quality and ensuring compliance with federal statutes. In the case of farming operations, however, the DNR has ceded responsibility to the Michigan Department of Agriculture (MDA). The MDA regulates environmental impacts of farming operations, including hogs, through a set of *Generally Accepted Agricultural Management Plans* (GAAMPs). If a farm is in compliance with the relevant GAAMPs then the DNR or MDA will take no action against it on the basis of federal or state environmental statutes. Permits for operation and manure disposal are not required for hog operations with less than 400 head. Larger operations may or may not require a permit, depending on a case by case review by MDA.

GAAMPs applicable to waste management on hog farms spell out design specifications for manure ponds, lagoons, and storage facilities. Runoff control is also required for any operation whose water runoff leaves the owner's property. Runoff can be controlled through construction of storage ponds, from which waste is later applied to the land, or the use of vegetative filters or

pasture systems. GAAMPs also require hog operations to be managed to minimize odor impacts on neighbors. Both feed and waste odors are a source of concern and the GAAMPs impose fairly specific requirements on storage of these materials.

GAAMPs also regulate applications of manure to the soil, not only with the aim of reducing odor problems for neighbors but also to ensure maintenance of soil quality. Nutrient status of soils, nutrient needs of crops, and nutrient analysis of manure are used to determine recommended application rates and strategies. Nitrogen and phosphorus control are particularly important issues. Excessive manure applications to soils can cause phosphorus to accumulate, which increases the risk of contaminating surface waters when runoff occurs, and results in excess nitrates being leached through the soil into groundwater.

The MDA is also responsible for administering a range of animal health regulations which require inspection of hog operations, restrict swine movements both in and outside the state, regulate vaccinations, and run a number of disease prevention programs. Provided hog operations satisfy these regulations, and otherwise comply with the relevant GAAMPs, then Michigan's right-to-farm law is designed to protect farmers from nuisance lawsuits. However, there have been few cases which interpret the Michigan Right-to-Farm Act and those that have occurred suggest the Act provides only limited protection when farming practices are changed after a change in local zoning ordinances, or when other issues such as public health and safety are at stake (Copeland and Hipp, 1994a p.77-78).

Overall, environmental regulations in Michigan are quite encouraging for small to medium sized hog operations. As long as these operations comply with the relevant GAAMPs they will generally not require a permit for operation or waste disposal, and will be afforded some protection from environmental liability and nuisance lawsuits. This is particularly true in the case of already established operations. On the other hand, new investment in very large operations may face substantial hurdles. Permits for operation and waste management may be

required and local zoning ordinances may place severe constraints on the size and location of these operations. Many areas of Michigan are densely populated which puts additional pressure on the zoning and quality of life conflicts between residents and large scale, intensive, livestock producers.

5. Industry Location

The most dramatic growth in hog production capacity and farm sizes over the last decade has occurred in a relatively small number of locations, generally outside traditional Corn Belt production areas. Much of this growth is associated with the large scale integrator-contracting systems which emerged in North Carolina and have been spreading to other states. Why did these integrators initially locate in North Carolina instead of the Corn Belt? Why are they continuing to locate in non-traditional hog production regions? What are the long-run implications for Corn Belt producers? These are difficult questions but we can gain some insight by examining four major factors which determine the location of new investments in hog production facilities.

- Cost of production.
- Transportation costs.
- The business and regulatory climate, including attitudes towards corporate farming.
- Self-reinforcement, or regional increasing returns to scale.

Cost of production is critical to hog industry location decisions. As shown earlier, the Corn Belt has a clear feed price advantage which has played a major role in the Corn Belt's historical leadership position. However, the feed cost advantage of the Corn Belt has declined with the emergence of the integrator-contracting system because the scale of operation allows large

quantities of feed to be purchased at favorable prices, and the latest technologies are applied to maximize feed conversion efficiency. Furthermore, additional weight is placed on labor and management costs in the integrator-contracting systems because they make more intensive use of hired labor. Labor costs are relatively high in many Corn Belt locations. Integrators also need a ready supply of farmers willing to undertake contract feeding. In North Carolina, the decline of the tobacco industry created a pool of farmers looking for ways to diversify out of tobacco production. Thus, the emergence of the integrator-contracting system has clearly reduced the traditional cost advantage enjoyed by Corn Belt hog farms and, at least in the case of smaller less efficient operations, eliminated this cost advantage altogether. Thus, we can expect to see more production growth in non-traditional areas in the years ahead.

Transportation costs have three main components—the cost of transporting feed to hog production facilities; the cost of transporting pigs and hogs to feeding operations and packers; and the cost of transporting pork products to wholesalers and retailers. The cost of transporting feed from the Corn Belt to other areas is a traditional explanation for the historical dominance of this region in hog production. On the other hand, the emergence of North Carolina and other states outside the traditional corn belt has highlighted the efficiencies in hog transportation costs that can be achieved by locating closer to major urban consumption centers. These two competing forces will continue to shape the regional distribution of hog production in the years ahead.

The business and regulatory climate, and attitudes towards corporate farming, are other important factors determining where new investment takes place. Anti-corporate farming laws and attitudes in Corn Belt states have made it difficult for large industrialized hog farms to operate in a number of locations, including Iowa and Indiana. Laws restrict hog farm size, limit the number of units which can be owned by a single operator, and preclude packers from owning hogs. But perhaps more important than the laws themselves are the attitudes of residents and

existing producers. The integrator-contracting system requires a ready supply of farmers willing and motivated to engage in contract feeding. If the attitudes of existing residents and farmers in an area are negative then it will be extremely difficult to implement an effective integrator-contracting system. The business and regulatory climate includes not only tax rates, energy prices, unemployment rate, off-farm employment opportunities, quality of schools and public services etc., but also environmental regulations and the degree of exposure to environmental liability. Stricter environmental regulations in a number of Corn Belt states have made it more difficult for large industrialized hog farms to obtain permits for producing and disposing of manure.

Finally, there is a factor influencing industry location which we might call *self-reinforcement*, or regional increasing returns to scale. This is the notion that firms benefit from the local presence of other firms in the industry, and from locational experience, so that locating additional operations within an existing region may entail less cost and risk than locating in an entirely different region. These factors lead to self-reinforcement, where firms might initially locate in a region by historical accident, or because it is temporarily advantageous to do so, and then regional economies kick in and encourage additional growth in that location (Arthur, 1988). This is an appealing intuitive explanation for the rapid initial growth of integrator-contracting systems in North Carolina. If self-reinforcement is important then it suggests that integrator-contacting systems may grow rapidly in other areas, once they have been initially introduced and begin to generate regional economies of scale.

These explanations for why hog production operations locate where they do, and why the major growth in integrator-contractor systems has occurred in North Carolina and other states outside traditional hog-producing Corn Belt regions, are logical and intuitive. However, there has been little research designed specifically to test these effects and determine their relative importance. Existing studies of why firms locate where they do have focused primarily on

manufacturing industries (e.g. Bartik, 1985; Carlton, 1983; McConnell and Schwab, 1990), and those that have addressed agricultural industries have tended to concentrate on cattle feeding and dairy (Langemeier and Finley, 1971; Byrkett, Miller and Taiganides, 1976). Yet the regional location of hog production facilities has considerable impacts on regional economies and if Michigan or any other state wants to encourage (or discourage) integrators from locating in their regions then it will be necessary to determine the significance of different factors contributing to the location decision.

6. Future Industry Structure and Location

How will industrialization in the pork sector evolve? Will large scale integrator-contracting systems come to dominate the industry? If there is a continuing role for smaller scale independent producers what will that role be? Will smaller scale independent producers be able to continue to find markets for their product? Where will major pork production and feeding areas be located in the years ahead? These kinds of questions are difficult to answer without a crystal ball but a number of general observations are possible.

- The growth of large scale integrator-contracting systems will continue, driven by production efficiencies, cost advantages, and the benefits from improved quality coordination.

- Much of this growth in integrator-contracting systems will occur outside traditional hog-producing areas. Feed prices are less important relative to labor and management costs in integrator-contracting systems and this has reduced the Corn Belt's comparative advantage. Location will increasingly be determined by wage rates,

labor supply, environmental regulations, land use conflicts, and attitudes to corporate farming, rather than by feed prices.

- The continued growth of the integrator-contracting systems will put tremendous pressure on operators using conventional production systems in traditional Corn Belt locations. Hurt (1994) has estimated that current U.S. pork supply could possibly be produced by about fifty producers and twelve packing plants if the integrator-contracting system becomes the norm. While this appears unlikely, at least in the immediate future, it is clear that many of the smaller, less efficient, producers scattered throughout the Corn Belt are going to be forced out of the industry.

- While Corn Belt operators will not necessarily have to adopt the integrator-contracting system to survive, they are going to have to adapt to the changes taking place in the industry. This means hog farms are going to have to continue to get bigger, and to continue adopting improved technologies and adapting them to local conditions. Some of the advantages of contract feeding may be achieved through cooperative agreements between independent producers specializing in various aspects of the hog production process.

- To be able to compete, Corn Belt producers and packers are also going to have to become increasingly sensitive to consumer preferences for pork, and to the advantages of a coordinated, consistent, high quality pork product. The integrator advantage of being able to supply high volume, high quality, uniform genetic stocks to packers may be overcome to some extent by cooperative agreements between independent producers and packers. The recent long-term agreement between the Michigan

Livestock Exchange and the Thornapple Valley packing plant in Detroit is an interesting example of this type of approach. However, it still remains to be seen whether smaller scale independent Corn Belt producers are going to be able to retain adequate market access in the years ahead.

- Economic conditions in the industry are going to have a major impact on the speed at which some of these changes take place. Favorable prices in the late 1980s and early 1990s led to a rash of expansions and new investments in the industry, much of it in large scale integrator-contracting systems. Falling prices and profitability will place considerable pressure on the industry, not only in the case of smaller less efficient operators but also on the large integrators. This could slow down the rate of investment and structural change, perhaps even leading some integrators to exit the industry.

Would the introduction of integrator-contracting systems into Michigan be good for the state? This is a difficult question but we can begin an answer by examining some alternative scenarios. To begin, suppose that all of Michigan's current hog production capacity was replaced by integrator-contracting systems using the latest technology to take advantage of economies of scale, and engaging in long-term contracts with packers to market their product. This is obviously a special, and somewhat extreme, case because it assumes that introduction of the integrator-contracting systems has no net supply effect (no change in the total production of hogs in the state), and that the integrator-contracting systems take over the entire industry (no smaller-scale independent producers remain). However, examining this extreme case will provide a baseline for evaluating economic impacts.

Currently in Michigan there are about 5000 hog farms producing about 500 million pounds of hogs per year. Assuming a 250 pound hog yielding 75 percent this implies about 2.66 million hogs per year. Now suppose these hogs are produced in an integrator-contracting system. How many sows would be needed to produce these hogs? Assuming 20 pigs per sow per year this would imply 133 thousand sows, which is approximately 40 farrowing units of 3400 sows each. Thus, with 3400 sow farrowing operations all of Michigan's current output could be produced with just 40 units. How many feeding operations would be needed to grow and finish these hogs? If it takes about 6 months to grow a hog to market weight and we assume the average feeding facility houses 2000 hogs then this implies about 660 feeding operations. Thus, the 5000 farms currently producing hogs in Michigan would be replaced by about 700 hog operations—40 farrowing units and 660 feeding units. Of course, these numbers could vary depending on assumptions made about the size of farrowing and feeding facilities but this seems to be in the right order of magnitude.

What would be the effects of these changes on the Michigan economy? Clearly there would be a net reduction in hog industry employment. Even if many of the current 5000 hog farmers only allocate part of their labor to hogs, the reduction to 700 production facilities implies a significant reduction in labor use. A small number of existing hog farmers may find employment managing a farrowing operation or contract feeding facility, but most will exit the industry to concentrate on other farm enterprises, or seek off farm employment. Reduced labor requirements are a good thing from an economic efficiency perspective because the industry is being more productive—the same amount of hogs are being produced with less labor. Furthermore, those fortunate enough to find employment in the new integrator-contracting systems may experience increased incomes. On the other hand, the majority of farmers that are forced out of the industry would presumably experience reduced incomes and/or face significant adjustment costs.

Reduced costs under the integrator-contracting systems would lead to an increase in profitability but profits would accrue primarily to integrators who may reside outside the state. Thus, at least some of these profits may be lost to the local economy. Direct marketing to packers would also lead to an increase in economic efficiency because fewer resources would be needed to market hogs. However, fewer resources means fewer jobs—businesses and workers currently marketing hogs would need to adapt or exit the industry. Moving to a large scale integrator-contracting system would also entail effects on regional economies within the state. Regions experiencing a decline in hog production would presumably be negatively affected while those in which the large-scale systems locate would receive a boost in employment and income.

What about effects on environmental quality? Environmental disamenities would be more concentrated under the integrator-contracting systems because there are fewer but larger production facilities. This means that the potential for conflicts over environmental disamenities would be reduced to a smaller number of geographic locations, but the scale of the effects at any one site would be magnified. Another trade-off is that monitoring and regulating waste management and runoff control may be easier in a more concentrated industry consisting of large scale firms than in a smaller scale, extensive, industry structure. There may also be more incentives for investing in improved waste management technologies in larger sized operations compared to smaller ones. One area of critical concern under an integrator-contracting system would be soil quality. Even if production is concentrated into smaller geographic areas, animal wastes may have to be spread over a relatively large surrounding area to avoid problems with nitrate problems and phosphorus build up. This is particularly true if wastes are not treated before they are spread.

The analysis so far assumes no net supply effect. Suppose now that the integrator-contracting systems could be introduced as an *addition* to current productive capacity in the state. That is, existing producers are able to maintain their position but integrators enter

Michigan and raise production levels. Clearly this would result in increased employment and economic development in the areas new farrowing and feeding operations locate. If the integrator-contracting systems could double Michigan's production capacity then there would be an additional 40 farrowing operations and 660 feeding operations, which would increase the economic contribution of the industry to state and local economies. It would also increase the demand for Michigan corn to feed the resulting increased supply of hogs. On the other hand, it would lead to reductions in environmental quality in areas where the new intensive production facilities locate, possibly leading to land use conflicts. Obviously there would be winners and losers under this scenario—the winners being those who benefit financially from the new economic development and the losers being those who suffer environmental disamenities, and possibly reductions in property values.

Finally, consider what might happen if integrators do not invest further in Michigan hog production. In this case it seems likely that Michigan producers will have increasing difficulty maintaining their market share and market access as the integrator-contracting systems continue to expand in other parts of the country. This would generate the negative economic effects associated with a decline in the current industry structure, including reduced output, employment, and profitability, without any compensating economic benefits from new investment in large scale integrator-contracting systems. The extent of this decline is open to debate and Michigan hog production has held up quite well so far. Nevertheless, it is clear that the continued growth of integrator operations in other areas, and a deterioration in market conditions, are going to put increasing pressure on Corn Belt producers, including those in Michigan. Problems with environmental disamenities and land use conflicts would presumably ease as production falls but at the cost of disinvestment and industry decline, with resulting negative implications for state and local economic development.

The scenarios discussed above are fairly extreme cases and actual future developments in the industry are likely to fall somewhere between them. However, the analysis does indicate some of the effects and trade-offs involved. It also emphasizes the fact that Michigan hog farms are going to face increasing pressure to either grow or exit the industry, irrespective of whether integrators start bringing their production systems into the state. Innovative strategic alliances, such as those being developed by the Michigan Livestock Exchange and Thornapple Valley, may also play an important role in future industry developments.

7. Concluding Comments

This report has examined trends and issues in pork sector industrialization, and traced out some of their implications for the Michigan pork industry. It is clear that industrialization is increasing, driven by adoption of new production systems, technologies and marketing arrangements. These integrator-contracting systems are low cost, high technology, and large scale. They typically engage in long-term contracts with packers so that production and marketing are coordinated to provide consumers and packers with the type of pork products they are demanding. It is a highly efficient system that has reduced the traditional feed cost advantage of the Corn Belt and made labor costs, labor availability, and the regulatory and business climate, much more significant determinants of hog industry location.

The implications of these trends for traditional Corn Belt hog-producing states, such as Michigan, are menacing. While the corn belt still enjoys a sizable advantage in feed costs, labor costs, environmental regulations, and attitudes towards corporate farming may make it difficult to encourage integrators into the corn belt, even if this was viewed as desirable. In the mean time, the growth of integrator contracting systems in non-traditional hog-producing areas has put continued pressure on Corn Belt hog farmers to adapt, grow, or exit. It is likely that these

trends will only exacerbate as the industry moves into a period of lower prices and reduced profitability where technical and cost efficiency are going to take on ever more prominent roles.

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