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U.S. Hog Production From 1992 to 2009: Technology, Restructuring, and Productivity Growth

William D. McBride and Nigel Key





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Abstract

U.S. hog farms declined in number by more than 70 percent over the past two decades while hog inventories remained stable. The result has been an industry with larger hog enterprises, increased specialization in a single phase of production, greater reliance on purchased feed rather than feed grown on the farm, and an increased reliance on formal contracts—connecting farmers, hog owners, and packers—to coordinate production. This structural change contributed to substantial productivity gains for hog farms, likely benefiting U.S. consumers in terms of lower pork prices and enhancing the competitive position of U.S. producers in international markets – though larger hog farms may increase environmental risks by concentrating production in areas with limited land available for manure application. With most hogs now grown on very large operations and with productivity-enhancing technologies widespread, the slowdown in hog farm productivity growth after 2004 suggests that the era of dramatic productivity gains will likely remain unmatched, absent significant technological innovation.

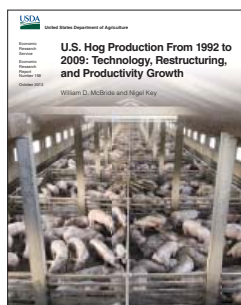
Keywords: Hogs, pigs, farm productivity, production contracts, pork prices, scale of production, farm structure, total factor productivity, concentration, Agricultural Resource Management Survey

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What Is the Issue?

Over the past two decades, hog producers have adjusted the size, organizational structure, and technological base of their operations; some have ceased hog production. The effects of these changes have extended beyond the industry as restructuring may have heightened environmental risks and nuisance impacts and lowered prices for pork consumers. In addition, the economic environment for pork producers changed as new uses for corn, the primary ingredient of hog feed, have increased feed prices. A slowdown in productivity growth after 2004 suggests that the era of dramatic growth in hog production is likely over, absent new technological innovation. This report presents information about changing structural characteristics and economic relationships in hog production, and discusses what these suggest for the future of hog farms.

What Did the Study Find?

The number of hog farms fell by more than 70 percent from 1992 to 2009 while the hog inventory remained stable. The average hog farm grew from 945 head of hogs sold or removed under contract in 1992 to 8,389 head in 2009. Specialized finishing operations (feeder-to-finish) increased their share of production from 22 to 77 percent during 1992-2004, while the share of production from farrow-to-finish operations fell from 65 to 18 percent. However, from 2004 to 2009 the shift toward operations specializing in a single phase of production slowed, and farrow-to-finish producers slightly increased their production share over this period. High corn and soybean prices during 2007-09 raised hog feed costs considerably. Declining hog farm numbers during this period suggest that many small, likely high-cost operations ceased production, adding to the average size of hog operations.

Hog operations organized under production contracts grew from 5 percent of production in 1992 to 67 percent in 2004. Operations producing under contract were larger than other operations and more likely to specialize in a single production phase. Between 2004 and 2009, the share of hogs produced under contract grew only 4 percentage points, to 71 percent. Few farrow-to-finish farms produce under contract. An expanded share of production from large-scale farrow-to-finish operations likely slowed growth in the use of production contracts on hog farms after 2004.

ERS is a primary source of economic research and analysis from the U.S. Department of Agriculture, providing timely information on economic and policy issues related to agriculture, food, the environment, and rural America.

The rapid growth of hog operations along the southeast coast of the United States during 1992-98 slowed in subsequent years partly because the North Carolina State legislature placed a moratorium on expanded hog production in the State (the leading hog producer in this area) in response to environmental concerns. In contrast, the size of hog operations increased more rapidly in the Heartland (mainly Iowa and Illinois) during 1998-2004 as contract production in this area expanded. This trend continued during 2004-09 as average production from both farrow-to-finish and feeder-to-finish hog operations increased in the Heartland.

Substantial productivity gains for hog farms since 1992 were attributable to increases in the scale of production and technological innovation. The increased size of operations accounted for almost half of the total increase in hog farm productivity since 1992. However, individual and total factor productivity growth on feeder-to-finish farms, where most market hogs are produced, slowed considerably between 2004 and 2009.

Productivity gains in hog production during 1992-2009 have likely benefited U.S. consumers in terms of lower pork prices, and enhanced the competitive position of U.S. producers in international markets. However, increases in the scale of production have resulted in greater animal density, creating possible environmental risks. On the other hand, increased feed efficiency accompanying structural change offset some of these risks as the waste per animal fell. In addition, concentrating manure sources in fewer locations potentially affects fewer people and may also make some manure treatment technologies (e.g., energy from bio-waste, or processing into concentrated fertilizer) feasible.

The era of dramatic productivity growth in hog production from 1992 to 2009 will likely remain unmatched, absent significant technological innovation. The 1992-2009 data support this conclusion on two fronts. First, the gains from exploiting scale economies are nearly exhausted, as most hog production now takes place at a size where returns to scale are nearly constant. Second, the measurable technological and organizational innovations contributing to productivity growth (e.g., confinement housing, production contracts, artificial insemination, all-in/all-out management) are now widely diffused.

How Was the Study Conducted?

Data used in this report come from USDA surveys of U.S. hog producers conducted for 1992, 1998, 2004, and 2009. Summaries of each data year were used to describe hog farm differences by producer type according to size, business organization, region, and production technology. A regression analysis was used to measure hog farm total factor productivity growth between 1992 and 2009 and decompose it into changes in four components: (1) technical change, the increase in the maximum output produced from a given level of inputs; (2) technical efficiency, the farm's ability to achieve maximum output given its set of inputs; (3) scale efficiency, the degree to which a farm optimizes the scale of its operations; and (4) allocative efficiency, a farmer's ability to choose a less costly mix of inputs to produce the same level of output. This study focused particularly on economies of scale, analyzing how increases in scale have contributed to productivity growth, and investigating whether scale economies in hog production have increased over time.

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Introduction

Background and Objective

The increasing size and specialization of operations reflect significant structural change in U.S. hog production during the past two decades. Once dominated by many small operations that practiced both crop and hog farming, the industry has become increasingly concentrated among large operations that produce hogs on several different sites. Further, large operations that specialize in a single phase of production (see glossary) have become the norm while the number of farrow-to-finish operations that perform all phases of production has diminished, and those remaining are much larger operations. Organizational change in hog production, particularly the widespread use of contracts with growers, enabled individual producers to grow by specializing in a single phase of production. Technological innovation has also been a driving force behind the industry's structural shift and has contributed to substantial increases in hog farm productivity.

This report examines trends and developments in U.S. hog production over the past two decades, analyzing changes in the characteristics, production practices, and production costs of U.S. hog operations, and evaluating structural and productivity trends. The objective is to emphasize economic relationships that have affected the size and ownership structure of hog production and the impact of these changes on industry productivity. The report provides data for 2009 (the latest survey results available) as an update to information on farm size, production costs, business arrangements, production facilities and practices, and farm operator and financial characteristics of the U.S. swine industry previously presented for 1992, 1998, and 2004 (McBride, 1995; McBride and Key, 2003 and 2007; Key and McBride, 2007).

This report relies on data from detailed surveys of U.S. hog producers for 1992, 1998, 2004, and 2009 (see box, "Data"). The target population of each survey was farms with 25 or more hogs on the operation at any time during the year. Screening out farms with hog inventories below 25 head excludes farms raising hogs primarily for onfarm consumption and other noncommercial activities, such as youth projects. Each sample included operations with hogs regardless of who owned the hogs, and thus included producers who raised hogs under contract with the hogs' owner. Therefore, results differ from those of surveys of hog *owners* (Boessen et al., 2004), where the sample population of hog owners includes very large operations with hogs produced under contractual arrangements on multiple sites (see box, "Hog Producers and Hog Owners").

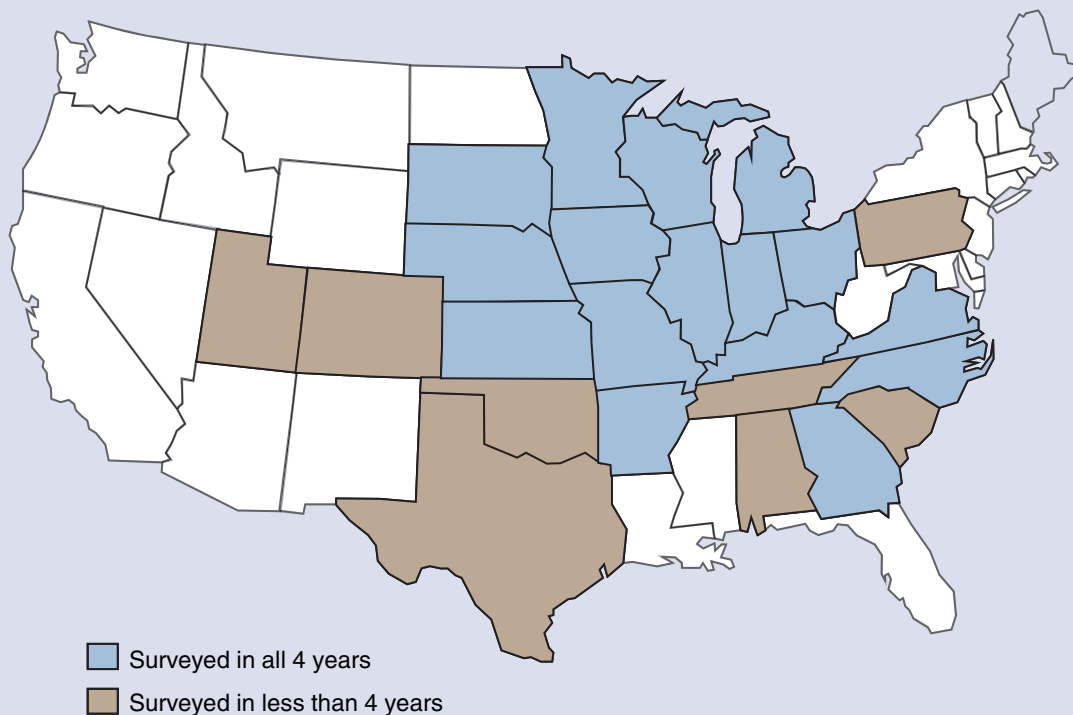
Data

Data for 1998, 2004, and 2009 come from USDA's Agricultural Resource Management Survey (ARMS), while data for 1992 come from the ARMS predecessor, USDA's Farm Costs and Returns Survey (FCRS). The surveys covered a cross-section of U.S. hog operations and collected information on farm size, production costs, business arrangements, production facilities and practices, and farm operator and financial characteristics. Producers in 16 States, including all major hog-producing States, participated in each of the 4 hog producer surveys (fig. 1). These 16 States represented nearly 90 percent of U.S. hog production in each survey year.¹

Figure 1

States as part of the 1992, 1998, 2004, and 2009 surveys of hog producers

Producers in the 16 States surveyed in all four years accounted for nearly 90 percent of the hog and pig inventory on U.S. farms in each year.



Note: The samples included 1,221 farms in 1992, 1,633 farms in 1998, 1,198 farms in 2004 and 1,289 farms in 2009.

Source: USDA, Economic Research Service.

--continued

¹Eight States were included in the ARMS survey at least 1 year, but not in all 4 years. The target for each survey was to account for at least 90 percent of the U.S. hog inventory in each survey year. Some States were added during a survey year to reach the 90-percent target, but were not needed in other survey years. An interest in studying the expansion of hog operations into western States accounts for some of the additional eight States.

Data (continued)

Each surveyed farm represents a number of similar farms in the population, as indicated by the surveyed farm's expansion factor. The expansion factor, or survey weight, was determined from the farm's selection probability and thereby expands the sample to represent the target population. The expanded samples in each survey represent more than 90 percent of the hog and pig inventory on U.S. farms in each survey year (USDA, NASS, Feb. 2010; Jan. 2006; Dec. 1995-2009). However, the hog samples expand to cover only about a third of the farm operations that had any hogs or pigs due to the 25-head threshold.²

Estimates from the surveys in 1992, 1998, 2004, and 2009 are comparable because of the consistent way in which the surveys were conducted and processed. Each survey had broad national coverage, represented the same target population (operations with 25 head or more), involved a complex sampling scheme designed to represent the target population, was conducted the same way (hand enumerated) by the same organization (NASS), and collected much the same information in a similar format. Also, the definitions of different types of hog producers used to summarize and present the data were identical in all 4 years.

The ARMS is a repeated cross section – operators are chosen randomly to participate in each survey; it is not a panel where the same operators are surveyed repeatedly. For this reason, some of the differences across time in average operator and operation characteristics result from the fact that different operators were selected for each survey, rather from actual changes in average characteristics. When differences across individuals are large and the sample is small, a panel may have greater statistical power to identify changes over time than repeated cross sections. However, in the past decades, a large number of operations have exited and entered the hog business and these operations differ substantially from continuing operations. For example, new entrants tend to be larger and exiting operations smaller than continuing operations (Key, 2013). A panel survey that samples only continuing operations would not provide an accurate perspective on the industry, making a repeated cross sectional survey preferable for the purposes of this study.

This study describes changes in the structure of hog producers defined as sites with 25 head or more hogs on the place during 2010, not necessarily the hog owners, because of the nature of the ARMS (see box, "Hog Producers and Hog Owners"). Significant changes in the structure of hog ownership also occurred during the study period, but due to data limitations an analysis of these changes is outside the scope of this report.

²Because of the minimum-size threshold, the share of farms with fewer than 100 head are significantly lower in ARMS than in NASS statistics. While these small hog operations represent about 70 percent of U.S. hog farms, they account for less than 1 percent of the hog inventory.

Hog Producers and Hog Owners

The rapid growth of contract production has increasingly separated hog production from hog ownership. Under contract production, a hog owner (a contractor) engages a producer (a grower) to take custody of the pigs and care for them in the producer's facilities. The producer is paid a fee for the service provided. Contractors typically furnish inputs for growers, provide technical assistance, and assemble the commodity to pass on for final processing or marketing. Contractors often market hogs through marketing contracts or other arrangements with packers or processors. Packers or processors also act as contractors and have production contracts directly with producers.

The data summarized in this report targeted farms with 25 or more hogs on the operation at any time during the year regardless of who owned the hogs. Therefore, the survey samples included operations where hog producers own their hogs as well as contract grower operations that are producing hogs owned by a contractor. Contractors are often large conglomerate or corporate organizations that contract with many growers to produce hogs. For example, Smithfield Foods, a packing company, was by far the largest contractor in 2009 with more than 900,000 sows (Successful Farming, 2010). In the survey data, information about the hogs owned by contractors such as Smithfield Foods is collected by contacting their contract growers.

Hog industry surveys can have different target populations and hence provide complementary, rather than duplicate, information. For example, data reported by Boessen et al. (2004) and Lawrence and Grimes (2001) are based on a survey of packers and other hog owners, who may have hogs on many different contract farms. The ARMS data are derived from a survey of sites with hog production facilities, which include farms with hogs under contract, farms owned by contractors, and independent operations that grow their own hogs and sell them locally or directly to packers.

NASS data show 8,150 fewer hog owners than hog producers (locations with hogs) in 2009, indicating that several hog owners had hogs on multiple operations. The hog inventory was also heavily concentrated among the largest owners, as those with 5,000 head or more owned 81 percent of the U.S. total. Of these, the largest 130 hog owners, those with 50,000 or more head, owned 57 percent of the inventory.

Head	Hog producers		Hog owners	
	Operations	Share of inventory	Operations	Share of inventory
	<i>Number</i>	<i>Percent</i>	<i>Number</i>	<i>Percent</i>
1-99	50,400	0.9	50,370	0.9
100-499	6,100	2.3	5,370	2.2
500-999	3,200	3.3	2,050	2.2
1,000-1,999	3,440	7.5	1,900	4.0
2,000-4,999	5,250	24.0	2,200	9.7
5,000 or more	2,950	62.0	1,410	81.0
U.S. total	71,450	100.0	63,300	100.0

Source: USDA, ERS using data from USDA, NASS, February, 2010.

Types of Hog Producers

The traditional approach of farrow-to-finish production—where breeding and gestation, farrowing, nursery, and finishing phases of production are performed on one operation—is being replaced by operations that specialize in a single production phase (see box, “A Primer on U.S. Hog Production”). In 1992, more than 50 percent of U.S. hog operations used the farrow-to-finish approach (fig. 2). By 2009, less than 25 percent were farrow-to-finish producers. In contrast, hog operations specialized in finishing hogs (feeder-to-finish) accounted for less than 20 percent of hog producers in 1992 but nearly 50 percent in 2009. Growing numbers of operations specializing in farrowing (farrow-to-wean) and the raising of weanlings (wean-to-feeder) provide further evidence of changing approaches to hog production.¹ These highly specialized operations, rarely reported in surveys prior to 2004, accounted for 11 percent of hog operations in 2009 (table 1). These specialized operations were also more likely to be producing hogs under contract (see glossary) than were farrow-to-finish farms.

The trend toward specializing in individual production stages is apparent in the relative number of years in business. Farrow-to-finish producers had been in business an average of 26 years in 2009, compared with less than 20 years for specialized farrowing, weanling, and finishing operations. Average operator age was also higher on farrow-to-finish farms, with a greater share of these operators (20 percent) over age 65 than on more specialized hog farms (11 percent).

Increasing specialization in hog production is also indicated by how important the hog enterprise is to the farm operation. Farrowing and weanling production occurred on farms with an average of \$1 million and \$830,000 respectively, of farm product value in 2009. Of that total, hog production

A Primer on U.S. Hog Production

The production of hogs to be slaughtered for pork is a process involving four phases: (1) breeding and gestation (breeding females and their maintenance during the gestation period), (2) farrowing (birth of baby pigs until weaning), (3) nursery (care of pigs immediately after weaning until about 30 to 80 pounds), and (4) finishing (feeding hogs from 30 to 80 pounds to a slaughter weight of 225 to 300 pounds). Hog producers are commonly classified by the number of production phases conducted on the operation into either: (1) farrow-to-finish (all four phases), (2) farrow-to-feeder (phases 1, 2, and 3), (3) feeder-to-finish (phase 4), (4) weanling-to-feeder (phase 3), and, (5) farrow-to-weanling (phases 1 and 2).

Most U.S. hog production historically occurred on farrow-to-finish operations in areas with an abundant supply of corn and soybeans. Hog farmers typically fed their hogs crops grown onsite and then sold their hogs at local markets. Beginning in the 1970s, hog production transitioned into partial or totally confined housing. Since then, advances in technology and management have made a science of hog production in large specialized buildings staffed with specialized labor. As part of the restructuring of hog production, operations became more specialized, typically conducting only a single phase of production before the hogs are moved to another operation or to market.

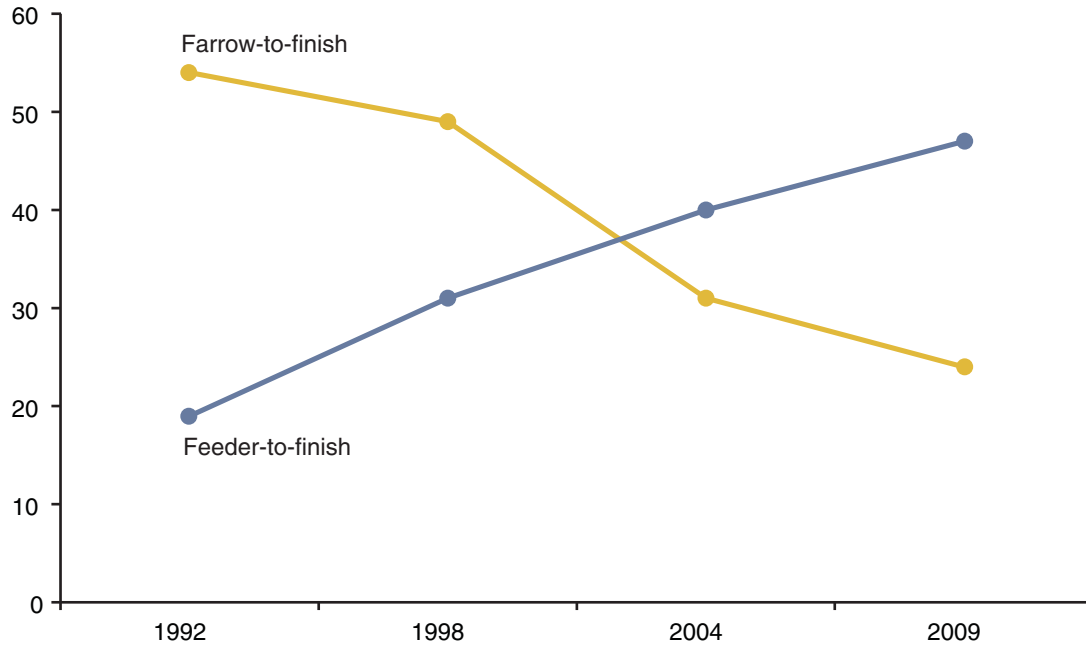
¹Specialized farrowing and weanling rearing operations provide feeder pigs to feeder-to-finish operations that finish hogs to a market weight. Hog-finishing operations may also obtain feeder pigs from other countries, mainly from Canada (USDA, ERS, 2012).

Figure 2

Hog operations by type, 1992 to 2009

Farrow-to-finish operations declined from more than 50 percent of operations to 23 percent, while specialized finishing operations went from 19 to 47 percent.

Percent of hog operations



Source: 1992 Farm Costs and Returns Survey; 1998, 2004, and 2009 Agricultural Resource Management Survey.

accounted for 84 percent of the value on farrow-to-wean operations and 76 percent on wean-to-feeder operations.² Hog finishing (feeder-to-finish) occurred on farms with an average production value of over \$1.2 million in 2009 (71 percent from hogs). Farm product value on farrow-to-finish operations was \$609,000 (58 percent from hogs) in 2009. Despite producing many more hogs, the hog producers that specialized in individual production phases generally had much less acreage than farrow-to-finish farms (table 1).³

More than 60 percent of all hog operations in 2009 were located in the Heartland (fig. 3), but the prevalence of different types of hog producers varies by region.⁴ For example, farms that finished hogs (farrow-to-finish and feeder-to-finish) were more often located in the Heartland where abundant feed supplies, primarily corn and soybeans, are available to finish hogs. Many farms that specialized in growing nursery pigs (wean-to-feeder) were located in the Southern Seaboard (23

²Hog producers often do not realize the value of production (net of production expenses) as farm income; in particular, contract growers receive fees for the growing services that are well below the value of the hogs when sold by the owner (see section titled Business Organizations). Contract growers are a large part of the specialized hog producer types surveyed in the ARMS.

³This is not to say that farrow-to-finish operations more often use the land directly for hog production, rather that farrow-to-finish operations have more land available to produce crops for hog feed and to dispose of hog manure than do other types of hog operations.

⁴These regions, constructed by the Economic Research Service, depict geographic specialization in the production of U.S. farm commodities.

Table 1

Characteristics and practices by type of hog producer, 2009

Item	Farrow- to-finish	Farrow- to-feeder	Feeder- to-finish	Farrow- to-wean	Wean- to-feeder	All producers
Characteristics:						
Percent of farms ¹	24	5	47	4	7	100
Percent using contracts ²	1	9	74	46	98	48
Years in hog business	26	22	16	17	19	19
20 yrs. or more (percent ³)	70	44	32	28	9	41
Operator age (years)	55	53	51	51	52	52
65 or older (percent ³)	20	18	11	9	8	14
College degree (percent ³)	19	21	20	24	23	21
Location (percent ³)—						
Heartland	56	12	76	50	60	62
Northern Crescent	16	22	9	7	7	11
Eastern Uplands	4	15	1	26	6	4
Southern Seaboard	5	8	9	7	23	10
Western regions ⁴	19	42	5	10	4	13
Farm Production (\$1,000)	609	208	1,260	1,040	832	938
Percent from hogs	58	78	71	84	76	70
Farm acres operated	811	213	685	446	451	662
Percent totally from hogs ⁵	12	26	14	30	21	16
Percent with no cropland ³	11	28	14	24	19	15
Practices:						
Facility age (years)—						
Farrowing	21	14	na	12	na	16
Nursery	17	13	na	na	11	12
Finishing	18	na	11	na	na	12
Farms (percent reporting ⁶)						
Artificial insemination	20	38	na	87	na	na
Terminal crossbreeding	30	23	na	52	na	na
Commercial seed stock	8	16	na	49	na	na
Genetics company	29	39	na	64	na	na
Phase feeding	44	na	73	na	na	na
All-in/all-out farrowing	58	35	na	56	na	na
All-in/all-out nursery	46	31	na	na	87	na
All-in/all-out finishing	34	na	84	na	na	na

Notes: "na" indicates not applicable.

¹Sum of percent of farms does not equal 100 because some farms could not be classified by type.

²Percent of farms using production contracts.

³Percent of farms.

⁴Includes the Prairie Gateway, Northern Great Plains, and Basin and Range regions (see fig. 3).

⁵Percent of farms where the value of farm production was totally from hogs.

⁶Some producers refused to respond or did not know the answer to a question. These figures are based on the percent of total producers who responded, excluding nonresponse.

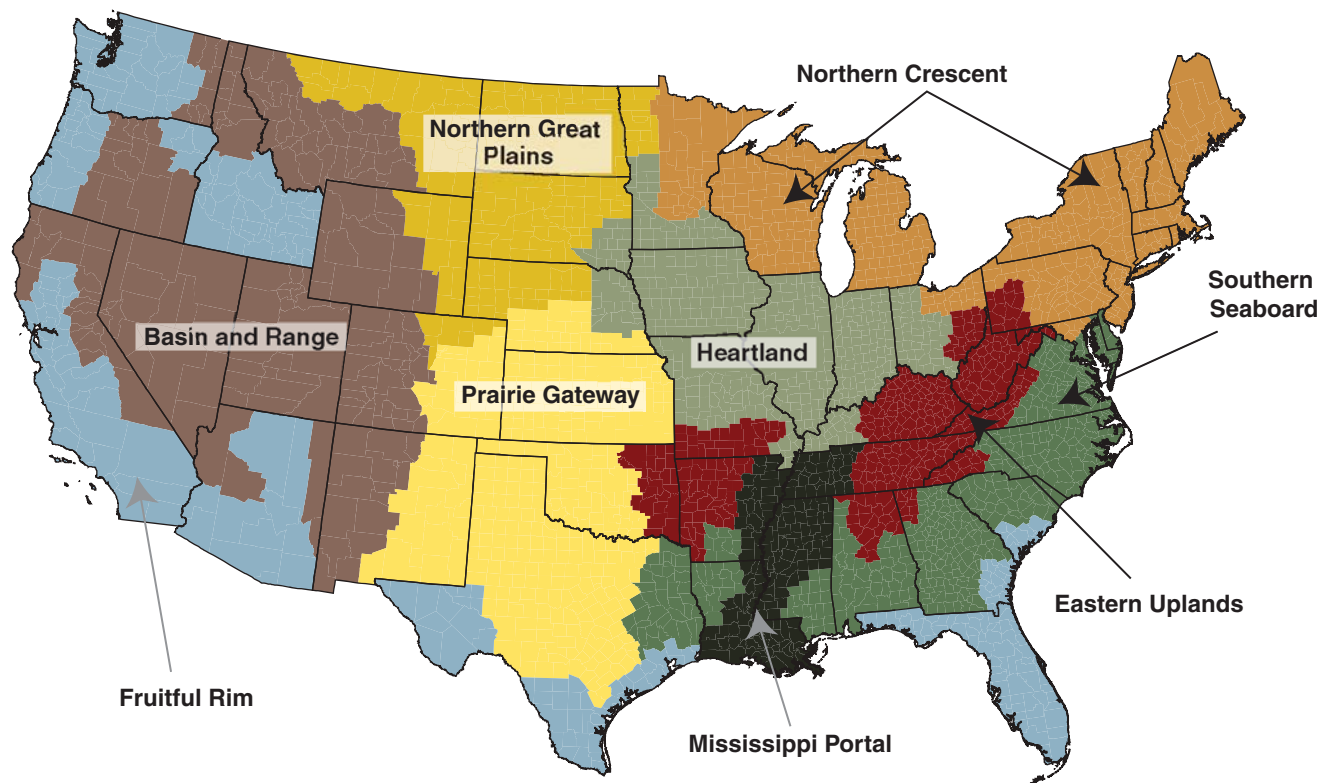
Source: USDA, ERS using data from the 2009 Agricultural Resource Management Survey.

percent of such farms). Farrow-to-feeder operations were prominent in the West (42 percent), suggesting that many of the weanling and feeder pigs produced in other regions are then transported to the Heartland for finishing.⁵

The technologies and practices used by the different types of hog producers varied widely. Age of facilities is an indicator of the technology employed. On average, hog operations specializing in individual production phases tended to have newer hog production facilities in 2009 than did the farrow-to-finish operations (table 1). Nursery and finishing facilities were also of a more recent vintage among the specialized weanling and finished hog producers. In addition, specialized farrowing, weanling, and finished hog producers were more likely to use improved technologies such as artificial insemination, terminal crossbreeding, commercial seedstock, and all-in/all-out management (see glossary).

Figure 3
Farm resource regions

Hog finishing is primarily done in the Heartland where abundant feed supplies, particularly corn, are available. Many farms specialized in weanling and feeder pig production are in other regions, mainly the Eastern Uplands and Southern Seaboard.



Note: The percent of hog producers in each farm resource region is shown in table 1.
 Source: USDA, Economic Research Service.

⁵ For example, Iowa included 17 percent of the breeding hog inventory in December 2009, but 30 percent of the market hog inventory (USDA, NASS, Dec. 2009). Some of the additional market hog inventory in Iowa and other States is from feeder pigs imported from Canada (USDA, ERS, 2012).

The remainder of this report describes the structure and productivity of farrow-to-finish and feeder-to-finish hog operations. These operations accounted for more than 70 percent of U.S. hog farms in 2009, and sufficient data are available to evaluate the structural and productivity trends of these farms from 1992 to 2009. Summaries of each data year are used to describe hog farm differences by producer type according to size, business organization, region, and production technology.

Changing Structure of Hog Production

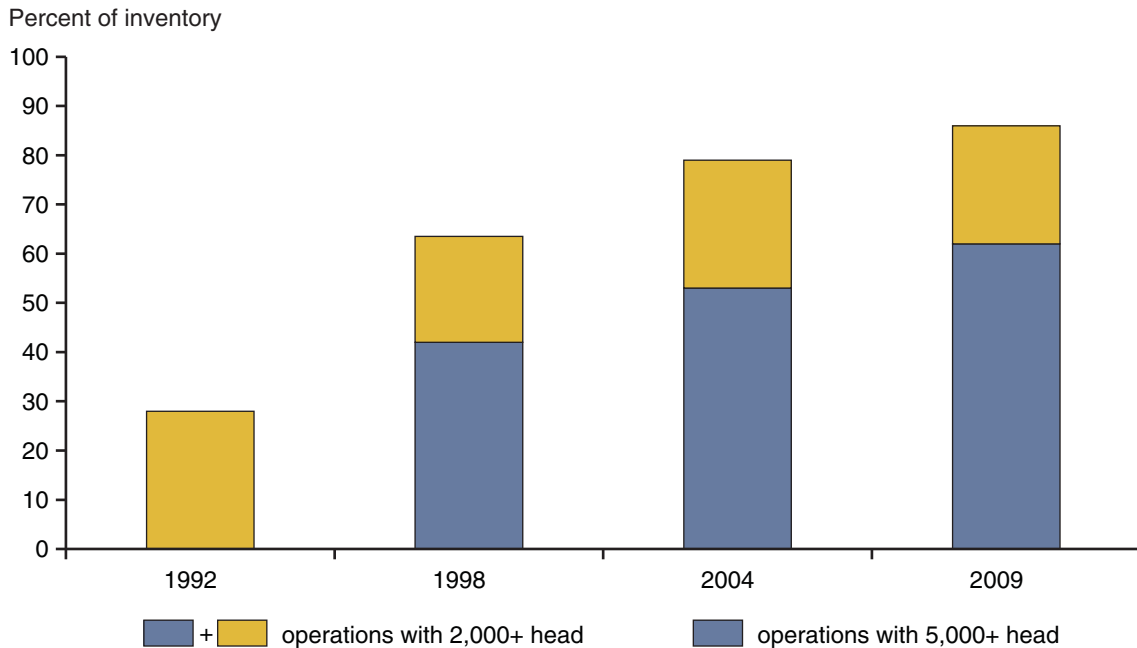
Size of Operations

The size of U.S. hog operations has changed dramatically during the past two decades. While the number of all farms in the United States remained fairly constant, the number of hog farms fell by about 70 percent between 1992 and 2009, from over 240,000 to about 71,000.⁶ Despite fewer hog farms, the Nation's hog inventory was stable during the period, averaging about 60 million head, with cyclical fluctuations between 56 and 68 million head (USDA, NASS, 1995-2009 and March 2010). Thus, hog production consolidated considerably as fewer and larger farms accounted for an increasing share of total output. From 1992 to 2009, the share of the U.S. hog and pig inventory on farms with 2,000 head or more increased from less than 30 percent to 86 percent (fig. 4). In 2009, farms with 5,000 head or more accounted for 61 percent of all hogs and pigs.⁷

Changes in the size of operations varied dramatically across different types of hog producers. The average size of farrow-to-finish operations grew 66 percent between 1992 and 2004, but then grew 170 percent from 2004 to 2009, increasing to 3,980 head (table 2). Specialized hog-finishing opera-

Figure 4
U.S. hog and pig inventory on the largest operations, 1992 to 2009

Farms with 2,000 head or more accounted for 86 percent of the total U.S. hog and pig inventory in 2009, up from 28 percent in 1992.



Source: USDA, NASS, December 1995-2009 and March 2010. Operations with 5,000+ head were not reported in 1992.

⁶Hog farms in this case refer to any place having one (or more) hog or pig on hand on December 31.

⁷Hog inventory is the number of hogs and pigs on an operation at a point in time. Often this is the beginning or end of a year, but may refer to the maximum number on the operation at any time during a year. In contrast, hog production refers to the flow of hogs on and off the operation during a year.

Table 2

Structural characteristics by type of hog producer, 1992-2009

Producer/Item	1992	1998	2004	2009
Farrow-to-finish				
Operations ¹ (percent of operations)	54	49	31	24
Market hogs sold/removed ¹ (percent of hogs)	65	38	18	20
All hog sales/removals (head per farm)	886	1,239	1,472	3,980
Contract operations (percent of operations)	*	*	*	1
Contract production (percent of hogs)	*	*	*	4
Farm product value from hogs (percent)	48	47	59	58
Farm-grown grain fed (percent of feed fed)	55	51	38	47
Feeder-to-finish				
Operations ¹ (percent of operations)	19	31	40	47
Market hogs sold/removed ¹ (percent of hogs)	22	55	77	73
All hog sales/removals (head per farm)	804	2,756	4,730	7,222
Contract operations (percent of operations)	11	34	50	74
Contract production (percent of hogs)	22	62	73	79
Farm product value from hogs (percent)	35	54	72	71
Farm-grown grain fed (percent of feed fed)	45	22	15	18
All hog and pig producers				
Operations ¹ (percent of operations)	100	100	100	100
Market hogs sold/removed ¹ (percent of hogs)	100	100	100	100
All hog sales/removals (head per farm)	945	2,589	4,646	8,389
Contract operations (percent of operations)	3	15	28	48
Contract production (percent of hogs)	5	40	67	71
Farm product value from hogs (percent)	46	56	67	70
Farm-grown grain fed (percent of feed fed)	49	35	19	26

Notes: * indicates less than 1 percent.

¹The sum of operations and sales/removals for the producer types will not equal 100 percent because not all producer types are shown (see table 1).

Source: USDA, ERS using data from the 1992 Farm Costs and Returns Survey and 1998, 2004, and 2009 Agricultural Resource Management Surveys.

tions were more than five times larger in 2004 than in 1992, and then grew another 80 percent between 2004 and 2009. The share of U.S. market hog production from farrow-to-finish operations decreased considerably from 1992 to 2004, but stabilized between 2004 and 2009. The increased size of farrow-to-finish operations from 2004 to 2009 compensated for the decline in the number of operations, so that the share of market hog sales from farrow-to-finish operations was up slightly in 2009 from 2004. Despite this rise, most market hog production takes place on feeder-to-finish operations. These operations accounted for more than 70 percent of market hog sales and contract removals in 2004 and 2009 (table 2).

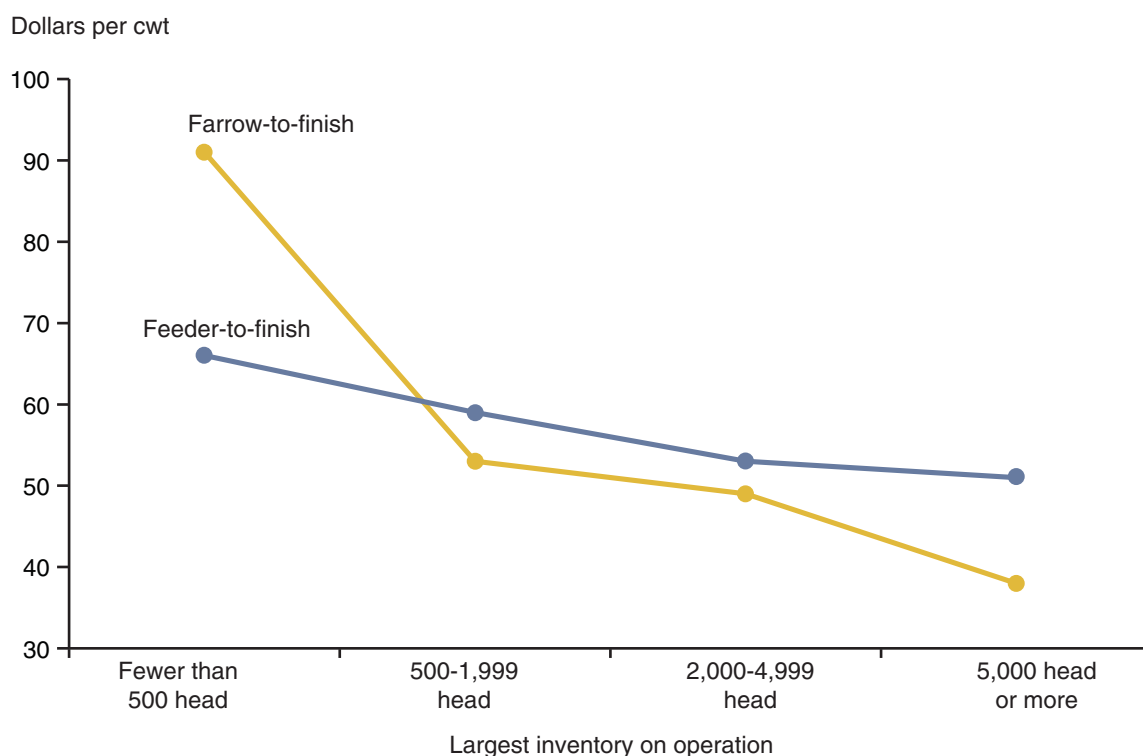
As hog farm size increased, so did specialization in hog production. For farms with more than 25 hogs, farm product value from hogs increased from 46 percent of total farm production value in

1992 to 70 percent in 2009. At the same time, farm-grown grain fed to hogs, as a share of total hog feed, declined nearly 25 percent as more hog feed was obtained from off-farm sources.⁸

Data from the 2009 ARMS show that average hog production costs are negatively correlated with operation size, particularly among farrow-to finish operations (fig. 5).⁹ The greatest difference in costs was between the smallest two sizes of farrow-to-finish operations, where average costs were 42 percent lower among operations with 500-1,999 head than for operations with fewer than 500 head. There were also significant cost differences between the largest two sizes of farrow-to-finish operations, where per-unit costs were 22 percent lower among operations with 5,000 head or more than for operations with 2,000-4,999 head. The largest farrow-to-finish operations were much larger than other farrow-to-finish operations, with an average production of 46,000 market hogs compared with about 4,500 head from operations in the 2,000-4,999 head group.

Figure 5
Cost of production by producer type and size, 2009

Average operating and ownership costs declined as size increased, especially among farrow-to-finish producers.



Source: 2009 Agricultural Resource Management Survey.

⁸Much of the changes in size, specialization, and farm-grown grain fed are associated with the growth of contract hog production, which is discussed in the next section.

⁹Hog production costs are computed using the ARMS data and secondary data on feed, labor, capital, and other production input prices (see <http://www.ers.usda.gov/data-products/commodity-costs-and-returns.aspx>). Average production costs refer to operating and ownership costs, defined in the glossary.

The cost-size relationship on farrow-to-finish operations likely contributed to the shift to much larger operations between 2004 and 2009. Also, prices for corn and soybeans, the major components of hog feed, rose significantly in 2007 and 2008. Corn prices moved to over \$3.00 per bushel (from about \$2.00 in 2005 and 2006) in 2007 and reached more than \$5.00 per bushel in 2008, while soybean prices reached more than \$13.00 per bushel in 2008, more than double its price of about \$6.00 per bushel in 2005 and 2006 (USDA, NASS, Agricultural Prices). High feed prices were an incentive for small, high-cost farrow-to-finish operations to exit the industry (perhaps to concentrate on crop production), resulting in the shift to much larger farrow-to-finish operations between 2004 and 2009.

Production costs varied much less among feeder-to-finish than among farrow-to-finish operations (fig. 5). Average production costs of feeder-to-finish operations declined with size by 23 percent from the smallest to the largest operations in 2009, but declined little for operations with 2,000 head or more. Also, most market hogs on feeder-to-finish operations were produced under contract.¹⁰ There is evidence that large contract operations had lower exit rates than similar non-contract operations between 2002 and 2007 (Key, 2013). Large contract growers, because they obtain much of their feed from contractors and because their compensation does not depend directly on hog prices, are better positioned than most non-contract producers to manage the input and output price risks of hog production.

Business Organization

Changes in the scale of hog production have been made possible, in part, by changes in the organizational structure of hog operations, as evident in the substantial growth of contract production (see glossary). Production contracts govern the relationship between growers (hog producers) and hog owners (“integrators,” or “contractors”), specifying the inputs provided by each party (feeder pigs, feed, labor, capital, energy, transport, and veterinary services and supplies) and the compensation due to each. Contractors typically retain ownership of the hogs on contract operations and provide the feed fed to the hogs. Growers typically provide the production facilities and labor, and are compensated based on a fee-for-service arrangement.

Such arrangements allow individual contractors to grow into substantial operations because the significant capital costs of hog production facilities are borne by contract growers. In 2009 and 2010, the three largest contractors owned about a quarter of the national sow herd (*Successful Farming*, 2010). Many of the largest contractors are also pork packers that are vertically integrated, obtaining hogs under production contracts directly with growers. Contract growers obtain economies of size by specializing in a single phase of production, and benefit from reduced exposure to changes in hog and feed prices.¹¹

Marketing contracts differ from production contracts, and typically govern the relationship between hog owners and hog packers. Marketing contracts specify expected hog quantities and qualities, the location and timing of delivery, and compensation, expressed as a hog price or a price formula. The same hog produced under a production contract between a contractor and grower can be sold to a

¹⁰Many of the production costs on contract operations were paid by the contractors. Feed and other input costs were obtained from information provided by contractors. Nursery and feeder pig costs were calculated using prevailing pig prices in 2009 (USDA, NASS, Agricultural Prices).

¹¹However, growers do face the risk of contractors failing or refusing to place pigs on their operations if there is a downturn in demand for pork products.

packer under a marketing contract between the contractor and a packer. In this report, contract operations refer to production contracts because the focus is on the growing stage, not on packer procurement (see box, “Hog Producers and Hog Owners”).

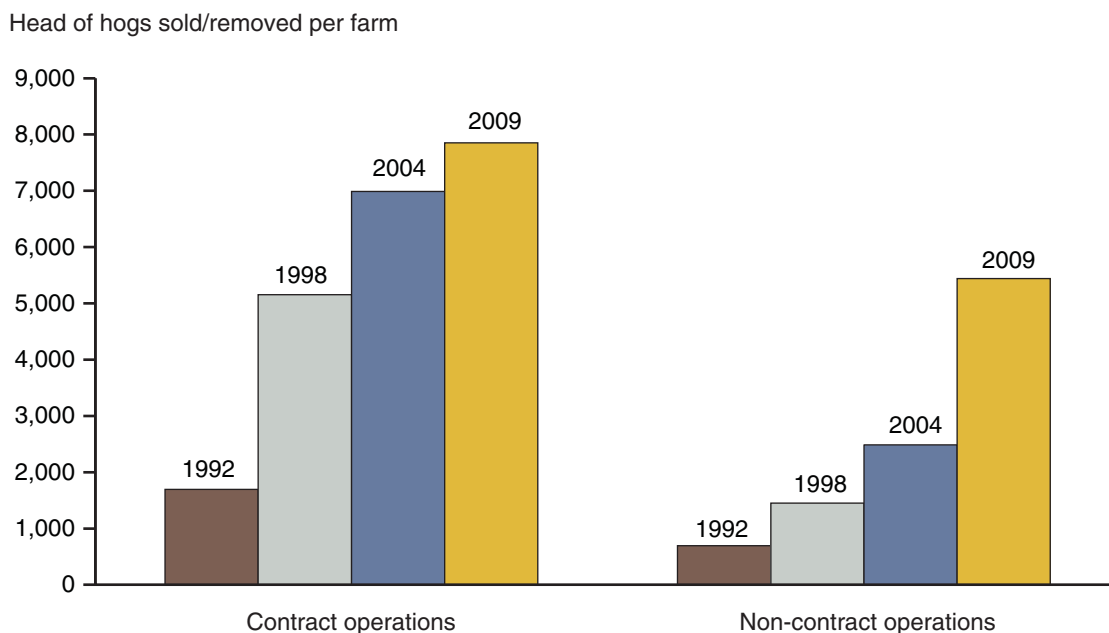
Hog operations with production contracts accounted for only 3 percent of overall U.S. hog operations and 5 percent of U.S. hog production (sales and removals) in 1992, but grew to 48 percent of operations and 71 percent of production by 2009 (table 2). Three-fourths of feeder-to-finish operations and nearly 80 percent of production on feeder-to-finish farms were under production contracts in 2009. Contract production had been virtually nonexistent among farrow-to-finish farms in years prior to 2009, but accounted for 4 percent of production in 2009.

The average size of hog finishing operations increased fastest from 1992 to 2004 for those producing under contract (fig. 6). Contract feeder-to-finish operations averaged about 1,000 more head produced in 1992 than did non-contract operations. By 2004, the difference had reached 4,500 head. Between 2004 and 2009, the increasing size of contract operations slowed, while the average size of non-contract hog finishing operations more than doubled from about 2,500 head to more than 5,400 head.

As with farrow-to-finish operations, high feed prices during 2008-09 created an incentive for small higher-cost hog finishing operations to exit the hog industry, and may underlie the shift to much larger non-contract feeder-to-finish operations by 2009. Many small non-contract hog finishing operations also produce corn and soybeans and with historically high crop prices during 2008-09 they may have decided to sell crops directly as opposed to feeding hogs. In 2009, hog finishing

Figure 6
Size of feeder-to-finish operations by business arrangement, 1992 to 2009

Average size of contract hog finishing operations was significantly greater than for non-contract hog finishing operations in each year, but the difference narrowed in 2009 as the size of non-contract operations grew more rapidly between 2004 and 2009.



Source: 1992 Farm Costs and Returns Survey; 1998, 2004, and 2009 Agricultural Resource Management Survey.

operations producing under contract were still much larger than non-contract operations, but the difference in size had narrowed from about 4,500 head in 2004 to less than 2,500 head (fig. 6). Contract hog finishing operations were less affected by higher feed prices, possibly because of their larger size and lower production costs, or because large contractors are less exposed to input price risk.

In 2009, the average farm value of production (for all commodities produced) on contract feeder-to-finish operations was nearly \$300,000 greater than on non-contract operations (fig. 7). The average value of hogs produced on contract operations was about \$400,000 more than what was sold from non-contract operations. However, average net farm income on non-contract operations was about \$60,000 higher than on contract operations. Much of farm income on contract operations was earned from fees paid by contractors, comprising a small percentage of the value of hogs produced. Despite having smaller operations, noncontract producers retained the value of hogs sold plus earned high prices for any crops produced and sold.

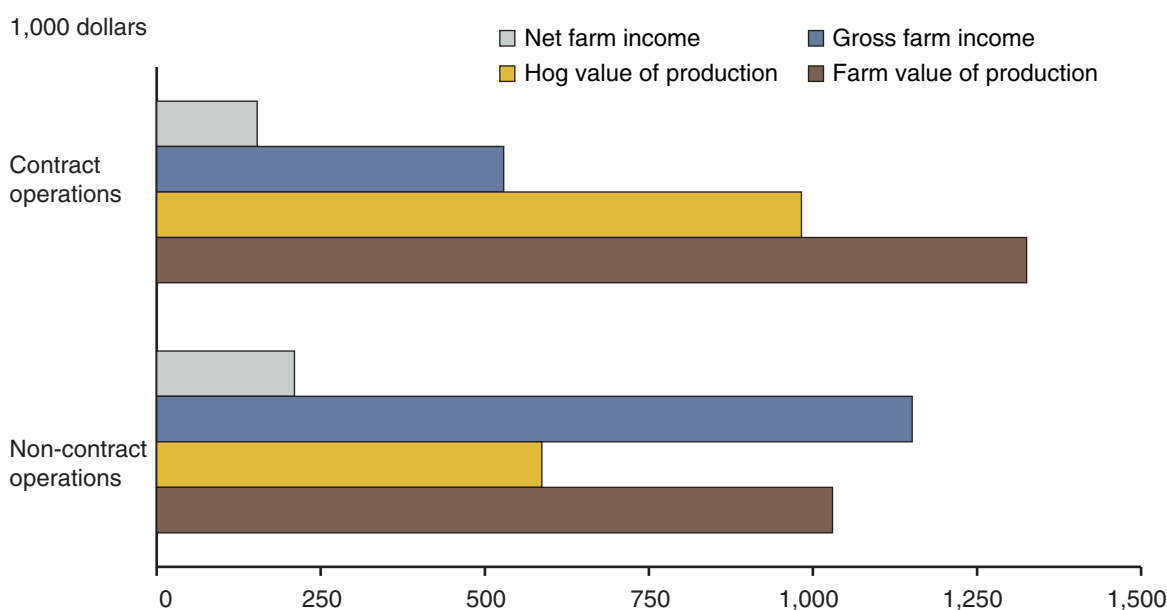
Regional Profile

Geographical shifts in hog production have accompanied the structural and organizational changes in the industry. Historically, hog production was concentrated in the Heartland (see fig. 3), where an abundant supply of corn and soybeans provided a cheap source of hog feed. During the 1980s and 1990s, hog production grew dramatically in nontraditional areas, driven mainly by the growth of large contract operations (Kliebenstein and Lawrence, 1995; Rhodes, 1995). For example, in North Carolina the inventory of hogs and pigs more than doubled between 1987 and 1992, as the State's rank in total hog inventory went from sixth to second, and then more than doubled again between

Figure 7

Farm value of production and farm income, feeder-to-finish operations, 2009

Average farm and hog values of production were greatest on contract operations in 2009, but gross and net farm incomes were greater on non-contract feeder-to-finish operations.



Source: 2009 Agricultural Resource Management Survey.

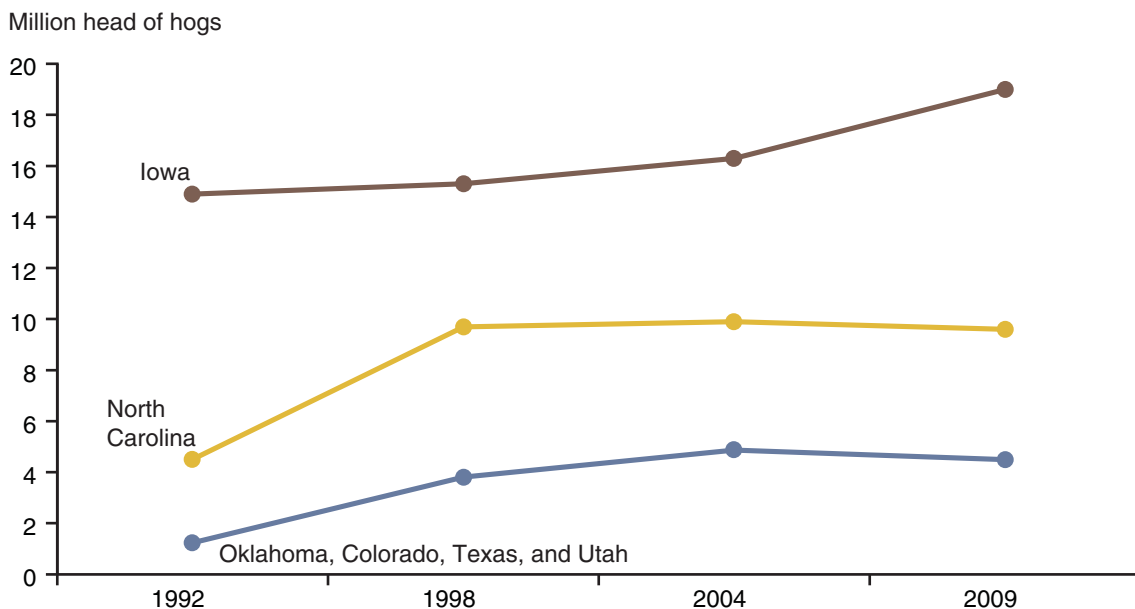
1992 and 1998 (fig. 8). Between 1992 and 2004, hog production also moved aggressively into Western States where the combined inventory of Oklahoma, Colorado, Texas, and Utah grew from 1.2 million to 4.9 million head.

Rapid growth in the North Carolina hog industry ended after a State law enacted in August 1997 placed a moratorium on the construction of new and expanded hog operations with 250 or more hogs (North Carolina General Assembly, 1997). The purpose of the moratorium was to provide State and local government time to adopt zoning ordinances and gather information on environmental impacts and alternative waste management technologies. Restricted growth in North Carolina may help explain the industry growth in Western States between 1992 and 2004. Open space and a relatively low population density in these States provide greater flexibility in managing animal waste. As the North Carolina moratorium continued through the 2004-2009 period, Iowa may have benefited as much of the hog industry growth during 2004-09 was in Iowa (fig. 8). The hog inventory in Iowa grew by 2.7 million head, or 17 percent, from 2004 to 2009.

Average production (sales and contract removals) per farm from Heartland hog operations grew steadily from just under 1,000 head in 1992 to more than 7,500 head in 2009 (table 3). Southern Seaboard operations (see fig. 3) increased average production per farm from 1,200 to nearly 20,000 head over that span, while in the Western region average production grew from 700 to more than 6,000 head per farm.¹² Average production by farrow-to-finish operations grew substantially in all regions from 1992 to 2009, up five-fold in the Heartland and 12 times higher in the West. Feeder-to-

Figure 8
Hog inventories in selected States, 1992 to 2009

*Hog numbers grew rapidly in North Carolina between 1992 and 1998, but little since 1998.
Hog numbers in Iowa grew significantly between 2004 and 2009.*



Source: USDA, NASS, December 1995-2009 and March 2010.

¹²Average size of operations in the Southern Seaboard is much larger than in the other regions partly because many of these operations specialize in a single production phase. The turnover of hogs from specialized operations is much higher than for farrow-to-finish operations, so hog/pig sales and removals are much higher.

Table 3

Regional hog and pig sales and contract removals by type of hog producer, 1992-2009

Producer/Item	1992	1998	2004	2009
Farrow-to-finish				
Heartland	901	1,288	1,851	4,482
Southern Seaboard	1,093	1,163	1,068	3,548
Western regions ¹	621	1,305	1,459	7,660
Feeder-to-finish				
Heartland	833	1,972	4,152	7,126
Southern Seaboard	1,035	10,951	12,057	11,180
Western regions ¹	358	3,589	3,255	7,841
All hog and pig producers				
Heartland	975	2,098	5,106	7,549
Southern Seaboard	1,206	10,021	13,995	19,952
Western regions ¹	702	2,231	1,859	6,232

¹Includes the Prairie Gateway, Northern Great Plains, and Basin and Range regions (see fig. 3). Source: USDA, ERS using data from the 1992 Farm Costs and Returns Survey and 1998, 2004, and 2009 Agricultural Resource Management Surveys.

finish operations also grew substantially in the Heartland and West regions, but average production per farm on operations in the Southern Seaboard remained much the same between 1998 and 2009, partly due to the North Carolina moratorium.

In contrast to earlier periods, farrow-to-finish operations in all regions grew much more from 2004 to 2009 than did specialized hog finishing operations (table 3). Average production per farm from farrow-to-finish operations in 2009 was more than two times higher in the Heartland, more than three times higher in the Southern Seaboard, and more than five times higher in the West than in 2004. This growth is partly the result of small farrow-to-finish operations exiting the industry when confronted with much higher corn and soybean prices. Market hog prices were less than \$50 per hundredweight during much of this period, creating a cost-price squeeze that would have been hardest on small, higher-cost producers.¹³ Also, new farrow-to-finish farms starting during this period would most likely have been large operations able to take advantage of economies of size.

The increasing size of feeder-to-finish farms accompanied rapid growth in regional contract production on these operations. The share of hogs finished under contract in the Heartland increased from only 4 percent in 1992 to more than 70 percent in 2009 (fig. 9). Contract production in the Southern Seaboard increased from 12 percent in 1992 to virtually all market hogs produced in 2004 and 2009. The 1992 survey did not measure any contract production of market hogs in the West, but by 2009 more than 80 percent were produced under contract.

Technologies

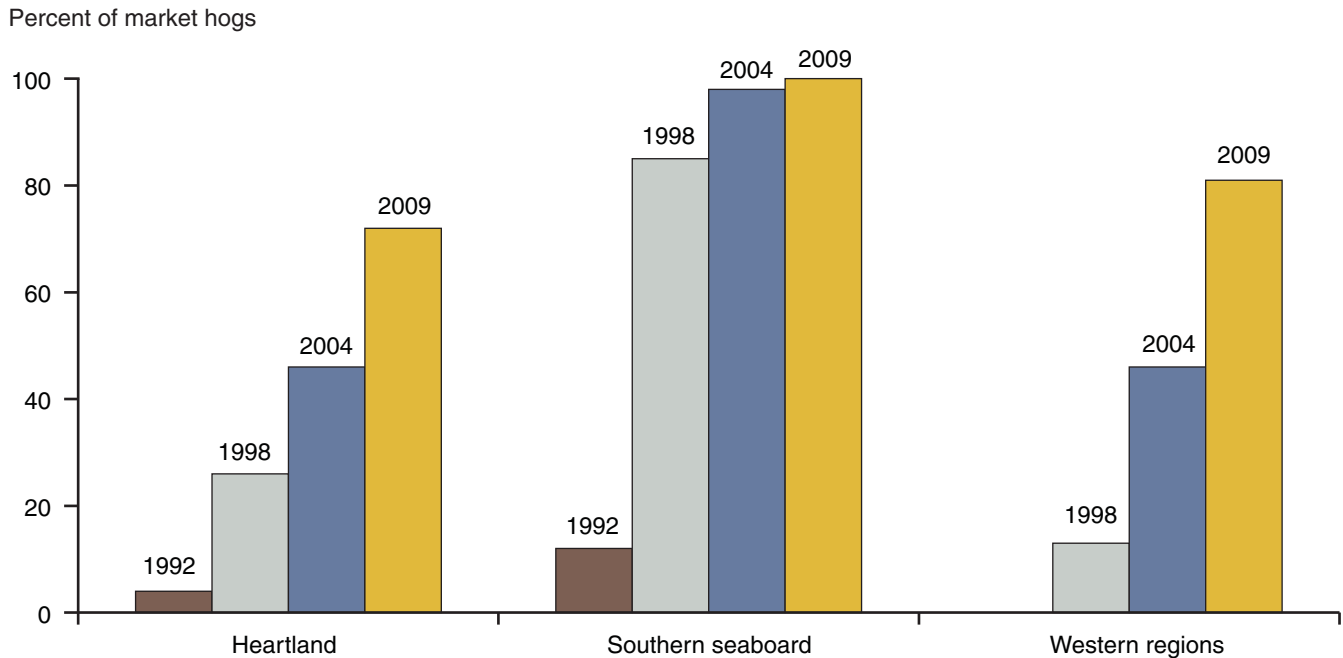
Like contract production, technological innovation has facilitated change in hog production. Technological innovation in hog production includes advances in genetics, nutrition, housing and

¹³Breakeven on the total costs for market hog production (feeder-to-finish) have been above \$50 per cwt since 2005 (USDA, ERS, 2013).

Figure 9

Market hogs removed under contract by region, feeder-to-finish operations, 1992 to 2009

The use of production contracts for finishing hogs increased significantly in the Heartland and Western regions from 2004 to 2009.



Source: 1992 Farm Costs and Returns Survey; 1998, 2004, and 2009 Agricultural Resource Management Survey.

handling equipment, veterinary and medical services, and management that improves the performance of hogs and the efficiency of the operation and/or reduces production risk.

Data from USDA’s National Animal Health Monitoring Service (NAHMS) surveys conducted in 1990, 1995, 2000, and 2006 indicate change in technological innovation on hog operations with 100 or more head (USDA, APHIS, 2008). For example, artificial insemination (AI) improves the genetic potential of the swine herd and the conception rates of breeding animals. The share of farrowing hog operations using AI increased from 7 to 23 percent between 1990 and 2000, and reached about 40 percent in the 2006 NAHMS data. Another innovative practice to enhance productivity, all-in/all-out housing management, commingles pigs of a similar age and weight and keeps the entire group together as it moves through each production phase. The hogs are marketed a room or group at a time, and rooms are washed and disinfected after each group leaves. The NAHMS data revealed that the use of all-in/all-out management for finishing hogs increased from 25 percent of hog operations in 1990 to 71 percent in 2006.

Both the 2004 and 2009 ARMS collected information about AI, all-in/all-out management, and other practices, including terminal crossbreeding programs, phase feeding, and feeding antibiotics by purpose (see glossary). The number of farrow-to-finish operations using AI, terminal crossbreeding, and all-in/all-out farrowing and finishing increased between 2004 and 2009 (table 4). Among feeder-to-finish operations, phase feeding and all-in/all-out finishing increased between 2004 and 2009.

Table 4

Technologies and practices used on hog farms, by type of hog producer, 2004 and 2009

Producer/Item	Percent of farms reporting ¹		Percent of production on reporting farms ¹	
	2004	2009	2004	2009
Farrow-to-finish				
Artificial insemination	12	20	62	84
Terminal crossbreeding	22	30	52	64
Phase feeding	48	44	67	66
All-in/all-out farrowing	43	50	70	66
All-in/all-out finishing	20	34	60	84
Antibiotics fed to nursery pigs for ² :				
Growth promotion	38	31	53	40
Disease prevention	62	55	67	60
Antibiotics fed to finishing hogs for ² :				
Growth promotion	43	23	59	40
Disease prevention	38	35	51	45
Feeder-to-finish				
Phase feeding	67	73	71	75
All-in/all-out finishing	79	84	88	84
Antibiotics fed to finishing hogs for ³ :				
Growth promotion	42	35	52	38
Disease prevention	58	49	64	50

¹Some producers refused to respond or did not know the answer to a question. These figures are based on the percent of producers who responded, excluding nonresponse.

²Nonresponse in 2004 was less than 1 percent for both nursery pig and finishing hogs. Nonresponse in 2009 was about 14 percent for nursery pigs and less than 5 percent for finishing hogs.

³Nonresponse in 2004 was less than 5 percent. Nonresponse in 2009 was between 20 and 25 percent.

Source: USDA, ERS using data from the 2004 and 2009 Agricultural Resource Management Surveys.

Larger farrow-to-finish farms more often used these practices than did smaller farms, as evident by the share of production on farms using these practices. For example, 20 percent of farrow-to-finish farms used AI in 2009, but these farms accounted for 84 percent of farrow-to-finish production. The share of farrow-to-finish farms using any one of the following technologies—AI, terminal crossbreeding, phase feeding, or all-in/all-out management—was at 50 percent or below in both 2004 and 2009, but a decided majority of farrow-to-finish production occurred on farms using these practices in both years. These practices were widely used on feeder-to-finish farms and accounted for a majority of production in both 2004 and 2009.

Antibiotic Use and Sanitary Practices

Antibiotics are fed to hogs at subtherapeutic levels for disease prevention and growth promotion (see box, “Subtherapeutic Antibiotics in Hog Production”). These antibiotics may be promoting the development of antimicrobial drug-resistant bacteria, prompting concerns that this resistance can spread to bacteria that infect humans (*Nature*, 2012; USGAO, 2011). In 2012, the U.S. Food and Drug Administration implemented a voluntary strategy to promote the judicious use of antibiotics that excluded antibiotics used for growth promotion (USFDA, 2012). In a survey of meat

Subtherapeutic Antibiotics in Hog Production

Subtherapeutic levels of antimicrobial drugs have been fed to hogs to prevent disease, promote growth, and improve overall animal health since the 1950s. The productivity of major inputs used in swine production—feed, labor, and capital—can be improved on some operations by feeding antibiotics. Possible modes of action for antibiotics include (1) nutritional effects, (2) disease prevention effects, and (3) metabolic effects (Cromwell, 2002). Feed efficiency can be increased by feeding low levels of antibiotics to improve nutrient absorption and depress the growth of organisms competing for nutrients. By suppressing disease-causing organisms in the animals' environment, antibiotics may reduce the incidence of diseases that hinder growth and thus raise the efficiency of labor and capital use. The 2004 ARMS data indicated a relationship between improved farm productivity and the feeding of subtherapeutic antibiotics to nursery pigs, but the impact of feeding antibiotics to finishing hogs was insignificant (McBride et al., 2008).

For many years, governmental and professional organizations have expressed concerns that the overuse of antimicrobial drugs in livestock production is promoting the development of antimicrobial drug-resistant bacteria (USFDA, 2012). Since many of the antibiotics commonly added to livestock feed and water are the same or similar to drugs used in human health care, the development of drug-resistant organisms would present a serious threat to public health. Such concerns prompted a European Union-wide ban on the use of antibiotics as growth promoters in 2006. In the United States, the use of subtherapeutic antimicrobial drugs in hog production has recently come under intense scrutiny from public interest groups and the U.S. Food and Drug Administration (FDA). In April 2012, the FDA implemented a voluntary strategy to promote the “judicious use” of antibiotics in food producing animals (USFDA, 2012). Among other things, the FDA asked the pharmaceutical industry to remove antibiotics for “production uses” such as feed efficiency and growth promotion from their FDA-approved product labels.

consumers, 86 percent of respondents thought that meat raised without antibiotics should be available in their local supermarket. Among the 13 largest supermarket chains, 1 offers nothing but meat and poultry produced without antibiotics and most offer some such products at prices that are not prohibitively higher (*Consumer Reports*, 2012).

Analysis of the ARMS data suggests that the use of subtherapeutic antibiotics in hog production declined between 2004 and 2009, possibly in response to consumer interest in and retail demand for pork produced without antibiotics. Fewer farrow-to-finish and feeder-to-finish producers fed antibiotics for growth promotion and disease prevention in 2009 than in 2004. The share of farrow-to-finish farms feeding antibiotics to nursery pigs declined 7 percentage points for both growth promotion and disease prevention (table 4), whereas the share feeding antibiotics to promote growth among finishing hogs declined 20 percentage points from 2004 to 2009. Among specialized hog finishers¹⁴, the share using antibiotics for growth promotion and disease prevention declined 7 and 9 percentage points, respectively, between 2004 and 2009.¹⁵ The share of production from these

¹⁴Nonresponse to the questions about antibiotic use was between 20 and 25 percent on feeder-to-finish farms in 2009, up from about 5 percent in 2004. Many nonrespondents produced hogs under contract and may not have known whether or not the feed provided by contractors included antibiotics.

¹⁵NAHMS data indicate a decline in feeding antibiotics for growth promotion to grower/finisher pigs of about 8 percentage points between 2000 and 2006 (USDA, APHIS, 2002 and 2009).

farms declined even more, 14 percentage points for both antibiotic-fed growth promotion and disease prevention.

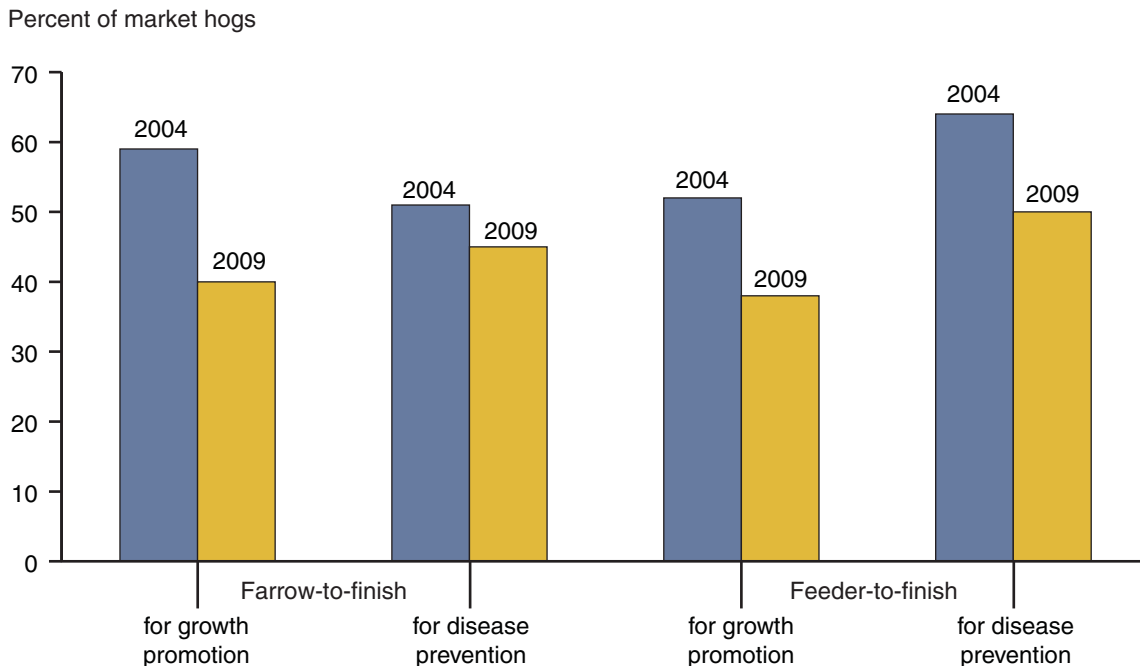
Much of the decline in antibiotic use has been among large hog producers. In 2004, nearly 60 percent of market hog production from farrow-to-finish farms was fed antibiotics for growth promotion; by 2009, this was down to 40 percent (fig. 10). Among feeder-to-finish operations, the use of antibiotics for growth promotion dropped from 52 to 38 percent of market hog production between 2004 and 2009. The share of market hogs fed antibiotics for disease prevention dropped 6 percentage points from 2004 to 2009 on farrow-to-finish farms and 14 percentage points on feeder-to-finish farms.

Antibiotic use declined among most sizes of farrow-to-finish operations between 2004 and 2009, but the percentage point decline was much greater among the largest operations (table 5). The smallest farrow-to-finish operations (under 500 head) used antibiotics least in both 2004 and 2009. Antibiotic use on feeder-to-finish operations also declined the most among the largest operations. Between 2004 and 2009, antibiotic use increased only among the smallest feeder-to-finish operations, but antibiotic use was still lowest among the smallest producers in both 2004 and 2009.

In addition to antibiotics, hog farmers use an array of strategies to prevent the emergence and spread of animal disease. Among these practices are restricting access (animals and humans) to production facilities, rodent control programs, bird proofing facilities, cleaning and disinfecting vehicles used to haul hogs, and preparing a written bio-security plan. It may be possible for sanitary practices like

Figure 10
Antibiotics fed to market hogs, by use, 2004 and 2009

The percent of market hogs on operations feeding antibiotics for growth promotion and disease prevention declined from 2004 to 2009.



Source: 2004 and 2009 Agricultural Resource Management Surveys.

Table 5
Antibiotic use, 2004 and 2009, and sanitary practices, 2009, by size of operation

Producer/Item	Fewer than 500 head	500-1,999 head	2,000-4,999 head	5,000 head or more
<i>Percent of farms reporting¹</i>				
Farrow-to-finish: nursery pigs				
Antibiotics for growth promotion: 2004	32	44	58	71
Antibiotics for growth promotion: 2009	17	51	67	36
Farrow-to-finish: finishing hogs				
Antibiotics for growth promotion: 2004	39	45	62	71
Antibiotics for growth promotion: 2009	9	39	59	48
Farrow-to-finish: 2009 sanitation practices				
Cats or livestock had access to facilities	74	71	37	10
Rodent control program used	63	84	100	93
Facilities bird proofed	11	39	60	81
Clean and disinfected vehicles hauling hogs	24	41	60	90
Written bio-security plan in place	8	16	26	75
Feeder-to-finish: finishing hogs				
Antibiotics for growth promotion: 2004	24	44	48	60
Antibiotics for growth promotion: 2009	29	39	33	40
Feeder-to-finish: 2009 sanitary practices				
Cats or livestock had access to facilities	59	21	12	14
Rodent control program used	66	87	90	95
Facilities bird proofed	25	77	93	86
Clean and disinfected vehicles hauling hogs	39	64	81	80
Written bio-security plan in place	13	30	51	73

¹Some producers refused to respond or did not know the answer to a question. These figures are based on the percent of total producers who responded, excluding nonresponse.

Source: USDA, ERS using data from the 2004 and 2009 Agricultural Resource Management Surveys.

these to at least partially offset the effect of restrictions that could be imposed on feeding antibiotics to hogs (MacDonald and Wang, 2011).

The largest farrow-to-finish operations were also most likely to use farm sanitary practices, including restricting the access of birds and other animals to the hog production facilities, cleaning and disinfecting vehicles used to haul hogs, and having a written bio-security plan in place (table 5). The striking differences in the use of antibiotics and sanitary practices between the largest and smaller farrow-to-finish operations may be related to hog volume. Operations in the 5,000-head-or-more group produced an average of nearly 46,000 head in 2010, compared with nearly 4,500 head in the next largest size group.

As with large farrow-to-finish operations, larger feeder-to-finish operations more often used several of the reported farm sanitary practices than did smaller operations. Most producers with 2,000 head or more restricted birds and other animals from the hog production facilities, cleaned and disinfected vehicles for hauling hogs, and had a written bio-security plan. However, the use of sanitary practices by feeder-to-finish operations varied much less across size groups than it did for farrow-to-finish producers.

Improvements in Hog Farm Productivity

Input Productivity

Substantial increases in hog farm productivity have been driven by and also reflect the industry's pronounced structural changes. Economic competition and the incentive to maximize profits drive structural changes in the hog industry. If larger operations are more profitable than smaller ones, competitive pressures are expected to result in a larger average farm size in the long run. Similarly, operations that are first to adopt a cost-saving technology, in regions with lower input costs, or closer to markets have a competitive advantage that makes them more likely to survive and grow. Relationships between farmers and processors also evolve to reflect more cost-effective modes of production. Since 1992, the use of production contracts has increased dramatically. The organizational structure of the industry also reflects efficiency gains from increased specialization in the various phases of hog production on separate operations.

The average quantity of inputs used in production per unit of output illustrates how efficiently individual factors of production are used on the farm. Such individual factor productivity measures allow for comparisons across regions or over time. ARMS collects detailed information about hog production, asking farmers about the amount and types of feed purchased, the amount of home-grown feed used, and hours spent working on the hog enterprise (both operator and paid/unpaid labor). ARMS also asks farmers about changes in their hog inventory and about the quantity and weights of hogs moved on and off the farm. This analysis measures output in terms of *hog weight gain*—the total weight added during the calendar year to born/purchased/placed hogs that were later sold/removed, plus the total weight added to the hog inventory. Hog weight gain—unlike the alternative output measure, number of head sold/removed—accounts for changes in inventory and for differences in the weights of feeder and finished pigs across operations.¹⁶

Before 2004, there were rapid increases in productivity on operations producing market hogs, especially on feeder-to-finish operations. Between 1992 and 2004 the average quantity of feed required per hundredweight of gain declined 14.9 percent (1.3 percent average annual decline)¹⁷ for farrow-to-finish operations and 44.1 percent (4.7 percent annually) for feeder-to-finish operations (table 6). The average quantity of labor used per hundredweight declined even more—falling 52.5 percent (6.0 percent annually) for farrow-to-finish operations from 1992 to 2004 and 83.1 percent (13.8 percent annually) for feeder-to-finish operations.

Since 2004, feed efficiency gains have continued apace on farrow-to-finish operations but have slowed on feeder-to-finish operations. Between 2004 and 2009, the average quantity of feed used per hundredweight of gain declined 3.3 percent annually on farrow-to-finish operations but only 0.7 percent on feeder-to-finish operations (table 6). Feed efficiency increased (that is, feed conversion decreased) on feeder-to-finish farms by 44 percent between 1992 and 2004, but only about 3 percent from 2004 to 2009 (fig. 11). On farrow-to-finish farms, feed efficiency improved 15 percent from 1992 to 2004, and nearly another 15 percent between 2004 and 2009.

¹⁶Each head produced represents approximately 2 cwt gain (250 pounds for a typical finished market hog minus 50 pounds for a typical feeder pig). Therefore, ignoring losses due to animal mortality, a farm with an output of 6,000 cwt gain sells or removes 3,000 head per year. Assuming 3 hog cycles per year, annual production of 6,000 cwt implies an operation has an inventory of 1,000 head.

¹⁷All annual rates of change are computed using the compound annual growth rate.

Table 6

Efficiency and production costs per hundredweight (cwt) by type of hog producer, 1992-2009

Producer/Item	1992	1998	2004	2009
Farrow-to-finish				
Feed conversion rate (lbs per cwt gain)	416	374	354	300
Labor rate (hrs per cwt gain)	1.13	0.72	0.54	0.48
Production costs, nominal dollars ¹	46.63	43.50	42.44	43.86
Production costs, 2009 dollars ¹	85.89	71.59	62.36	43.86
Feeder-to-finish				
Feed conversion rate (lbs per cwt gain)	383	282	214	207
Labor rate (hrs per cwt gain)	0.89	0.24	0.15	0.12
Production costs, nominal dollars ¹	37.54	31.08	26.59	37.62
Production costs, 2009 dollars ¹	69.22	51.35	39.69	37.62

¹Production costs are the sum of operating and ownership costs less costs for feeder and nursery pigs. Pig costs are excluded because they are not an input contributing to weight gain. 1992, 1998, and 2004 feed costs are deflated to 2009 dollars using the national agricultural feed price index; other costs are deflated to 2009 dollars using the national agricultural production items index (USDA, NASS, Agricultural Prices). In 2009, feed costs accounted for 58 percent of the costs of farrow-to-finish production and 74 percent of the costs of feeder-to-finish production.

Source: USDA, ERS using data from the 1992 Farm Costs and Returns Survey and 1998, 2004, and 2009 Agricultural Resource Management Surveys.

From 1992 to 1998, the labor hours required to produce a hundredweight of hogs declined substantially—about 73 percent on feeder-to-finish and nearly 36 percent on farrow-to-finish operations (table 6). Between 2004 and 2009, the rate of labor efficiency gains slowed, with labor used per hundredweight of gain declining about 10 percent for both farrow-to-finish and feeder-to-finish operations (fig. 12).

Productivity gains contributed to a decline in production costs between 1992 and 2004 (table 6). For farrow-to-finish hog producers, average production costs per hundredweight of gain, expressed in 2009 dollars, were 27 percent lower in 2004 than in 1992.¹⁸ This change amounts to a 2.6-percent average annual rate of decline. Inflation-adjusted costs declined faster for feeder-to-finish hog producers, falling 43 percent between 1992 and 2004, or 4.5 percent annually.¹⁹

Substantial productivity gains continued after 2004 for farrow-to-finish operations: the nominal cost of producing a hundredweight of hogs was only about 3 percent higher in 2009 than in 2004, despite feed prices that increased more than 50 percent (table 6). After adjusting for price changes, production costs declined in real terms by nearly 30 percent. In contrast, nominal production costs for feeder-to-finish operations increased 41 percent from 2004 to 2009; after adjusting for price changes, production costs declined 5 percent over this span.

Sources of Productivity Growth

Increases in input efficiency and declining average costs illustrate the magnitude of the productivity gains in the hog sector. Sources of this productivity growth are examined by estimating changes in

¹⁸Feed costs are deflated to 2009 dollars using the national agricultural feed price index; other input costs are deflated to 2009 dollars using the national agricultural production items index (USDA, NASS, Agricultural Prices).

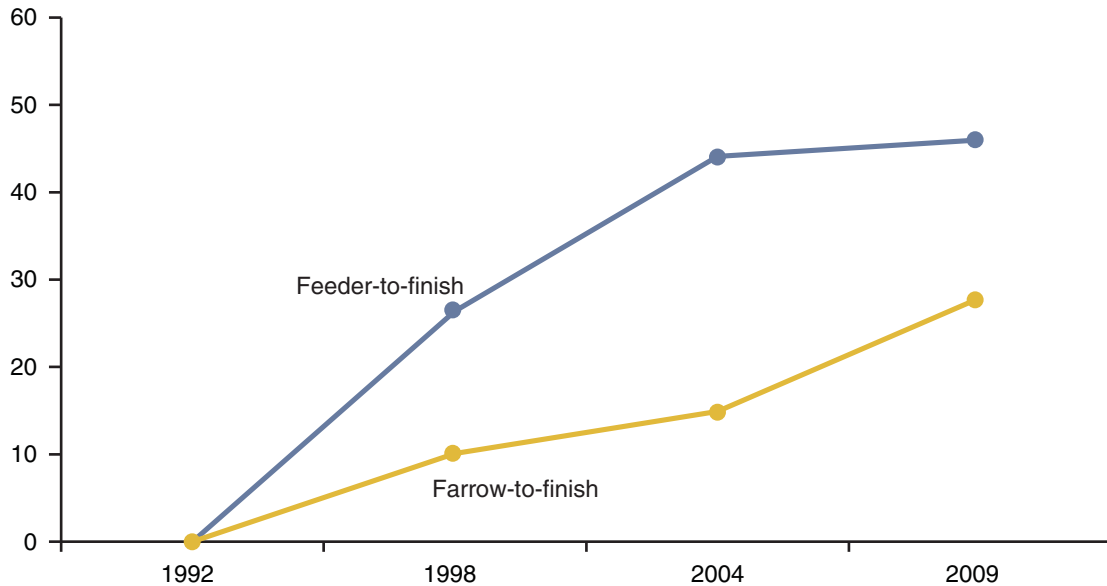
¹⁹The increased labor productivity impact on production costs has been, to some extent, offset by higher wages paid to hired workers on larger and technologically advanced farms (Yu et al., 2012).

Figure 11

Feed efficiency improvement, 1992 to 2009

The rate at which feed efficiency improved declined between 2004 and 2009 for feeder-to-finish operations, but increased among farrow-to-finish operations.

Percent improvement from 1992 (pounds per cwt gain)



Source: 1992 Farm Costs and Returns Survey; 1998, 2004, and 2009 Agricultural Resource Management Survey.

total factor productivity (TFP)—an aggregate measure of productivity that reflects how efficiently inputs are converted into outputs. A farm’s TFP will reflect the production technology it uses (which determines the rate at which inputs can be combined to make outputs), whether it is operating at an efficient scale of production, how efficiently inputs are combined given the production technology available, and how well the farmer takes into account the relative prices of inputs.

The production technology used by a farm is a fundamental determinant of its productivity. In hog production, the production technology incorporates livestock genetics, feed mixtures and feeding equipment, housing and handling equipment, and veterinary and medical services used. The term *technical change* (or *progress*) describes the increase in productivity resulting from adopting more efficient production technologies.

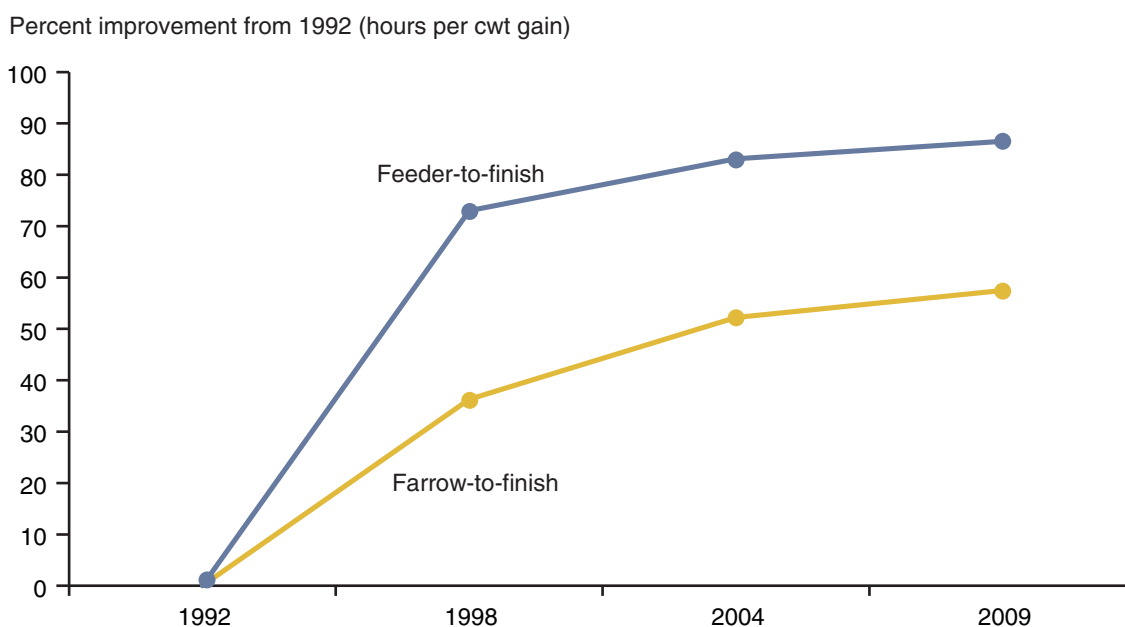
An increase in the scale of production is another source of productivity growth when there are increasing returns to scale—that is, when a proportional increase in all inputs results in a more than proportional increase in output. The returns to scale of a particular production technology are measured by its “scale elasticity”—the percentage increase in output obtained from a 1-percent increase in the quantity of all inputs.²⁰ The movement toward the optimal scale of production (the scale at which the scale elasticity equals one) is said to increase *scale efficiency*.

²⁰For example, if a farm has an estimated scale elasticity of 1.25, then a 1-percent increase in all inputs would result in a 1.25-percent increase in output. Scale elasticity above 1 implies increasing returns to scale. Having increasing returns to scale is not optimal because productivity could be higher if output were increased. Scale elasticity equal to one implies constant returns to scale—that is, there is no productivity gain (or loss) from increasing the scale of production. Scale

Figure 12

Labor efficiency improvement, 1992 to 2009

Labor efficiency improved greatly between 1992 and 1998, but less in successive years between 1998 and 2009 for both feeder-to-finish and farrow-to-finish operations.



Source: 1992 Farm Costs and Returns Survey; 1998, 2004, and 2009 Agricultural Resource Management Survey.

Table 7 shows the evolution of production costs (inflation-adjusted dollars per hundredweight gain) for farms in different size categories. Costs have declined for most farm size categories. In addition, the data strongly suggest increasing returns to scale in each survey year, with declining per unit production costs as the scale of production increases. Some of the decrease in average unit costs since 1992 (see table 6) likely resulted from growth in the size of surviving operations. That is, between 1992 and 2009, some farms responded to the economic incentive to reduce average costs by expanding the scale of their operations; some smaller, less efficient operations exited the industry; and new operations entered at a larger, more efficient scale.

It is also likely that some of the differences in productivity growth rates between farrow-to-finish and feeder-to-finish operations since 2004 (table 6) were associated with differences in the rates of farm size growth. Farrow-to-finish operations expanded rapidly between 2004 and 2009—the average operation sold/removed 1,472 head in 2004; this grew to 3,980 head in 2009 (see table 2). Output from feeder-to-finish operations also grew substantially over this period, but at a slower rate—increasing from 4,730 head in 2004 to 7,222 head in 2009.

While increases in scale efficiency and technological change are likely the largest sources of productivity growth, hog farms also may become more productive by increasing technical and allocative efficiency. Holding the scale of production and the technology constant, *technical efficiency* increases if farmers use inputs more efficiently in the production process. For example, a farm manager might increase technical efficiency by carefully blending the contents of feed to maximize

elasticity below one implies decreasing returns to scale—efficiency would actually decline if production were increased. Decreasing returns to scale is also suboptimal because productivity could be higher if output were decreased.

Table 7

Production costs per hundredweight (cwt) by type and size of hog producer, 1992-2009¹

Producer/Size category	1992	1998	2004	2009
	\$/cwt			
Farrow-to-finish				
Cwt gain<1,000	105.45	109.18	110.71	102.73
1,000≤cwt gain< 2,500	92.27	83.15	76.89	74.24
2,500≤cwt gain<10,000	80.04	72.25	62.81	64.37
10,000≤cwt gain<25,000	78.96	64.09	60.50	47.12
25,000≤cwt gain	id	61.87	54.41	36.59
Feeder-to-finish				
Cwt gain<1,000	90.32	80.60	62.47	64.81
1,000≤cwt gain< 2,500	67.25	72.16	50.88	46.34
2,500≤cwt gain<10,000	63.81	55.50	47.27	44.52
10,000≤cwt gain<25,000	id	46.24	37.20	35.88
25,000≤cwt gain	id	47.22	37.79	32.79

¹Production costs are the sum of operating and ownership costs less costs for feeder and nursery pigs. Pig costs are excluded because they are not an input contributing to weight gain. 1992, 1998, and 2004 feed costs are deflated to 2009 dollars using the national agricultural feed price index; other costs are deflated to 2009 dollars using the national agricultural production items index (USDA, NASS, Agricultural Prices). In 2009 feed costs accounted for 58 percent of the costs of farrow-to-finish production and 74 percent of the costs of feeder-to-finish production.

id = insufficient data for legal disclosure.

Source: USDA, ERS using data from the 1992 Farm Costs and Returns Survey and 1998 and 2004 Agricultural Resource Management Surveys.

animal weight gain per unit of feed. The farmer does not use a new technology or produce more, but the productivity of the farm increases because input expenditures per unit decline. Farmers increase *allocative efficiency* if they can improve productivity by choosing a less costly mix of inputs that produces the same level of output. For example, if the price of feed increases relative to the price of capital, then it becomes more efficient to substitute capital for feed (say by using machinery that more accurately rations feed).²¹

Disaggregating Productivity Growth

In this section, we disaggregate productivity growth at one important stage of hog production—feeder-to-finish—which now accounts for most finished hog output (73 percent in 2009).²² Disaggregating the observed increases in total factor productivity into technical change, technical efficiency change, scale efficiency change, and allocative efficiency change provides insight into the forces that drive structural change. The methodology used here to disaggregate TFP follows Orea (2002), and is described in more detail in Key and McBride (2007) and Key, McBride and Mosheim (2008). The approach requires estimation of a production frontier—a parametric relation-

²¹In addition to increases in hog farm productivity caused by these sources, there have also been substantial productivity gains at the industry level from increasing specialization in the various stages of hog production. As production shifted from less efficient farrow-to-finish operations to more efficient specialized operations, the total costs of producing finished hogs industrywide declined substantially, resulting in industrywide improvements in productivity. Too few farrow-to-wean or wean-to-feeder pig operations were in the ARMS data to access industry-wide gains from increased specialization in this study.

²²There were too few observations to conduct a similar analysis for farrow-to-finish operations.

ship between input quantities and the maximum output achievable from those inputs. The frontier describes the amount that technically efficient operators could produce if they used the best practices available in the industry. Since no producers are perfectly technically efficient, production occurs within the frontier.

The assumed functional relationship between the inputs and output is “flexible” in that it imposes few *a priori* restrictions on the characteristics of the production technology, such as constant returns to scale. The parameters describing the frontier are estimated using a maximum likelihood technique that accounts for the facts that: (1) we do not observe the distance of the actual production levels from the frontier, and (2) input and output levels are measured with error (Battese and Coelli, 1992).

By definition, the percentage change in TFP equals the sum of technical change plus changes in technical efficiency, scale efficiency, and allocative efficiency. Consistent with the trends in production costs (see table 6), the rate of TFP growth slowed substantially for feeder-to-finish operations after 2004 (table 8).²³ While TFP almost doubled between 1992 and 2004, it grew just 8.4 percent between 2004 and 2009. The annual rate of TFP growth slowed from 6.7 percent in 1992-98 to 5.6 percent in 1998-2004 to just 1.6 percent in 2004-09.

Technological change and increases in scale efficiency accounted for most of the growth in TFP since 1992, but their contribution to TFP growth has been shrinking over time. The rate of technical change slowed from 3.0 percent annually between 1992 and 1998 to 2.3 percent between 1998 and 2004 to 1.0 percent between 2004 and 2009. The increases in scale efficiency slowed even more rapidly: scale efficiency increased 4.2 percent annually between 1992 and 1998, 2.2 percent between 1998 and 2004, and only 0.9 percent between 2004 and 2009. Average technical efficiency changed

Table 8
Decomposition of total factor productivity change, feeder-to-finish operations, 1992-2009

Producer/Item	Change over period (Annual growth rate)		
	1992-1998	1998-2004	2004-2009
	<i>Percent</i>		
Technical efficiency	-2.9 (-0.5)	3.3 (0.5)	-2.7 (-0.6)
Technical	19.6 (3.0)	14.5 (2.3)	5.2 (1.0)
Scale efficiency	28.1 (4.2)	13.9 (2.2)	4.5 (0.9)
Allocative efficiency	2.6 (0.4)	7.1 (1.1)	1.4 (0.3)
Total factor productivity	47.3 (6.7)	38.8 (5.6)	8.4 (1.6)

Source: Authors' calculations using data from USDA's 1992 Farm Costs and Returns Survey and USDA's 1998, 2004, and 2009 Agricultural Resource Management Surveys.

²³Estimates for 1992-2004 shown in table 8 differ from those in Key and McBride (2007). Differences result because we estimate the stochastic production frontier using all available surveys. The estimates for 1992-2004 in table 8 are functions of parameters that were estimated with the addition of the 2009 data, which were not available in the earlier study.

little over the 17-year study period. Allocative efficiency change also played a small role in TFP change—increasing at an annual rate of 0.6 percent from 1992 to 2009.

Implications for Scale of Production

Increases in scale efficiency contributed significantly to productivity gains between 1992 and 2009 as hog farms grew to take advantage of increasing returns to scale. Estimates of returns to scale explain farmers’ incentives to further expand farm size.

The top half of table 9 shows the change over time in the share of hog output produced by feeder-to-finish farms in each farm-size category. This period is characterized by a shift in production toward the largest operations. Farms producing at least 10,000 hundredweight gain represented less than 10 percent of total output in 1992. By 1998, these operations produced nearly 65 percent of total output, and their share rose to 90.9 percent by 2009.

The bottom half of table 9 reports the estimated scale elasticity for hog farms in each size category and the mean scale elasticity for all farms in each survey year. The scale elasticity declines as farm size increases—large farms obtain smaller gains from increasing scale than do small farms. In every year, the mean scale elasticity was greater than one, implying increasing returns to scale in all periods. However, as farm size increased between 1992 and 2009, the share of farms in the larger size categories increased, which caused the mean scale elasticity to decline over time from 1.15 to 1.04. The mean scale elasticity of 1.04 in 2009 indicates that a 10-percent increase in inputs produces a 10.4-percent increase in output for the “typical” farm.

Farms producing less than 10,000 hundredweight could substantially improve productivity by increasing their scale of production. However, beyond about 10,000 hundredweight gain, the

Table 9
Share of output and scale elasticity by farm size and year, feeder-to-finish operations, 1992-2009

Size category	1992	1998	2004	2009
	<i>Share of total output (percent)</i>			
cwt gain < 1,000	14.7	1.9	0.5	0.1
1,000 ≤ cwt gain < 2,500	35.0	6.7	3.0	1.0
2,500 ≤ cwt gain < 10,000	41.0	26.5	16.7	8.0
10,000 ≤ cwt gain < 25,000	9.3	29.2	36.3	46.1
25,000 ≤ cwt gain	id	35.7	43.4	44.8
	<i>Scale elasticity</i>			
cwt gain < 1,000	1.20	1.23	1.21	1.26
1,000 ≤ cwt gain < 2,500	1.12	1.14	1.14	1.13
2,500 ≤ cwt gain < 10,000	1.06	1.08	1.07	1.07
10,000 ≤ cwt gain < 25,000	1.05	1.04	1.03	1.01
25,000 ≤ cwt gain	id	0.97	0.96	0.97
All farms (mean)	1.15	1.13	1.09	1.04

id = insufficient data for legal disclosure.

Source: USDA, ERS using data from USDA’s 1992 Farm Costs and Returns Survey and USDA’s 1998, 2004, and 2009 Agricultural Resource Management Surveys.

productivity gains from expanding farm size appear limited. Farms producing between 10,000 and 25,000 hundredweight had an average scale elasticity of 1.01 in 2009. The technology used by farms in the largest size category (greater than 25,000 hundredweight) exhibits slightly negative returns to scale. In 2009, about 91 percent of hog output from feeder-to-finish operations originated on farms producing at least 10,000 hundredweight gain. Hence, there appears to be little scope for additional productivity gains from increases in scale for feeder-to-finish operations using current technologies.²⁴

Regional Differences

Production, farm size, and productivity growth on feeder-to-finish hog operations varied substantially by region between 1992 and 2009 (table 10). We compare trends in two major hog-producing regions: the Heartland and the Southern Seaboard (see fig. 3). Producers in the West and other regions are placed in the “other regions” category.²⁵

Between the first two surveys (1992-98), production shifted from the Heartland to the Southern Seaboard and other regions. The share of output produced by farms in the Southern Seaboard increased 12.5 percentage points, even though the share of feeder-to-finish operations located in this region declined 6.1 percentage points. An almost tenfold increase in scale of production (cwt gain) accounts for this increase in output share. The Heartland experienced smaller proportional increases in average farm output over 1992-98, so its share of total output declined by 15.8 percentage points.

After 1998, this pattern reversed; feeder-to-finish output share rebounded in the Heartland and declined in the Southern Seaboard. From 1998 to 2004, Heartland farms doubled in size while farms in the Southern Seaboard had much smaller proportional increases (though starting from a larger average size). As a result, the Heartland increased its share of output 10.6 percentage points over this period, while the Southern Seaboard experienced a decrease in share of 6.7 percentage points. This trend continued from 2004 to 2009; Heartland farms increased in size much faster than did those in the Southern Seaboard. Over the most recent period, Heartland farms increased their share of total output by 13.9 percentage points, while those in the Southern Seaboard saw their share of output decline by 9.6 points.

The decline in output share and the slow growth in average farm size in the Southern Seaboard during 1998-2009 are likely attributable to policy changes in North Carolina, which produced about 96 percent of total hog output in the Southern Seaboard region. In 1997, the Clean Water Responsibility and Environmentally Sound Policy Act imposed a moratorium in North Carolina on the construction of new and expanded hog operations with 250 head or more.²⁶

In 1992 and 1998, the average hog operation in the Southern Seaboard was more productive than the average farm in the Heartland (table 10)—partly reflecting the substantial difference in average farm size between the regions. (Productivity is measured as output per dollar of inputs, where input

²⁴This study used data from operations (i.e., sites) that had hogs and not from the hog owners that include large multi-state, multipacker integrators. Many of the feeder-to-finish operations in this study produced hogs for large integrators. A limited scope for productivity gains from hog operations larger than those most often observed in this study may be a reason why large integrators don't have all their hogs in one place, but rather have hog operations at several sites.

²⁵In this section, regions are defined differently than in Key and McBride (2007).

²⁶The moratorium contained several exceptions, including new construction using “innovative animal waste management systems that do not employ an anaerobic lagoon.” For full text of the bill, see: <http://ssl.csg.org/dockets/99bscbills/2499b01nchb515cleanswine.html>

Table 10
Output and productivity trends by region, feeder-to-finish operations, 1992-2009

Item/Region	1992	1998	2004	2009
	<i>Percent</i>			
Share of farms				
Heartland	65.3	71.8	68.9	75.9
Southern Seaboard	14.2	8.1	10.0	9.5
Other regions	20.5	20.0	21.0	14.6
Share of output				
Heartland	67.5	51.7	62.3	76.2
Southern Seaboard	18.1	30.6	23.9	14.3
Other regions	14.4	17.7	13.7	9.5
	<i>Hundredweight gain</i>			
Mean farm output				
Heartland	1,665	5,753	10,971	19,059
Southern Seaboard	2,040	22,848	26,740	28,398
Other regions	1,384	11,738	14,420	13,253
	<i>Hundredweight gain per dollar of inputs¹</i>			
Productivity index				
Heartland	0.013	0.016	0.028	0.028
Southern Seaboard	0.016	0.021	0.023	0.024
Other regions	0.012	0.015	0.017	0.021

¹ Input costs are the sum of feed, labor, capital recovery, and other input costs. The labor expenditures for paid labor are observed. Labor expenditures for unpaid labor are estimated using an imputed wage for unpaid labor. Other inputs are expenditures on veterinary services, bedding, marketing, custom work, energy, and repairs. The cost of each input is expressed in 2009 constant dollars using Bureau of Labor Statistics (BLS) price indices: the BLS blue collar total compensation index is used for labor, a weighted average of the corn and soybean Producer Price Index (PPI) for feed, the farm machinery PPI for capital, and a weighted average of fuel and pharmaceutical PPIs for other inputs.

Source: USDA, ERS using data from USDA's 1992 Farm Costs and Returns Survey and USDA's 1998, 2004, and 2009 Agricultural Resource Management Surveys.

expenses are adjusted to 2009 price levels.) Between 1998 and 2009, the average farm size in the Heartland continued to grow at a rapid pace, while it stagnated or grew slowly elsewhere. By 2004, the productivity advantage reversed—the average hog farm in the Heartland was more productive.

Differences in productivity across regions can be partly explained by differences in input prices, since the productivity index is based on input costs. Operations in the Heartland, a major corn and soybean producing region, enjoy cheaper feed costs than farms in other regions. In 2009, farms in the Heartland had an average feed cost of \$14.76 per cwt, compared with \$18.81 per cwt in the Southern Seaboard and \$27.80 per cwt in other regions.²⁷

²⁷Average feed costs are the sum of purchased and homegrown feed costs. Purchased feed costs are reported directly by producers, or obtained from hog contractors. Quantities of reported homegrown feed are valued according to feed grain and soybean market prices.

Organizational Structure and Productivity

Production contracts offer several potential advantages over independent production that help explain their growing use: contracts can reduce information asymmetries between growers and processors, improve coordination and timing of product delivery, and lower income risk for growers. Production contracts also may raise farm productivity by improving the quality of farm management decisions, speeding the transfer of technical information to growers, improving growers' access to credit, and facilitating the adoption of more efficient technologies.

ERS research has shown a link between the use of production contracts and hog farm productivity. Using the 1998 ARMS survey of feeder-to-finish hog farms, Key and McBride (2003) compared the productivity of similar independent operations and contract operations, controlling for unobservable differences that might be associated with the decision to contract. The authors found that production contracts were associated with an average increase in total factor productivity of about 23 percent. In a second study using the more recent 2004 ARMS, Key and McBride (2008) used an instrumental variables technique to isolate the effect of contracts on productivity. As in the earlier study, the authors found that contract operations were substantially more productive than similar independent operations. A 10-percent increase in the prevalence of contracting would increase average total factor productivity by 5 percent. Estimates of the magnitude of productivity gains attributable to contracting suggest that these productivity advantages contributed to the growth in hog contracting during 1992-2009.

The share of feeder-to-finish operations using production contracts grew from 11 percent in 1992 to 74 percent in 2009 (table 2). This growth in contracting by feeder-to-finish operations may have contributed to the productivity gains enjoyed by the sector. However, by 2009, 79 percent of hogs produced by feeder-to-finish operations were raised under a production contract, suggesting limited scope for productivity gains from a further expansion in the use of production contracts.

Implications of Structural and Productivity Change

The dramatic structural changes in the hog industry and the resulting productivity gains have enhanced national economic efficiency by freeing up land, labor, capital, and other resources for the production of other goods and services. These changes have helped lower pork prices for consumers and contributed to an increase in U.S. pork exports. On the other hand, in some States these changes have concentrated livestock manure in regions with relatively little available cropland for spreading, making it more costly to apply as fertilizer in environmentally benign ways.

Lower Consumer Prices

One of the main benefits to society from increased productivity on hog farms is lower pork prices for consumers. Lower production costs for farmers will generally mean lower prices for hogs at the farm gate (compared to what they would have been without the productivity increases). Lower hog prices will, in turn, lead to lower pork prices if packers and retailers pass along their cost savings to consumers. How much have productivity gains in hog production been reflected in prices? One way to address this question is to estimate how much hog prices would have increased had there been no change in farm productivity. This counterfactual can be estimated by examining input prices. In a competitive market, the price received by farmers for finished hogs equals the total cost of inputs, including a “normal” rate of return on owners’ equity. Consequently, if the normal rate of return was constant and farm productivity did not change, then hog prices would be expected to track input prices.

Input price trends between 1992 and 2009 are shown by the real aggregate input price index (fig. 13). The price index is a weighted sum of the inflation-adjusted feed (47 percent), capital (22 percent), labor (23 percent), and other input (8 percent) prices, and is set to 100 in 2005.²⁸ The inflation-adjusted input price index did not display a clear trend until about 2006, after which it increased substantially in response to large feed price increases. The input cost index had an average value of 104 in the first 3 years of the series (1992-94) compared to 141 in the last 3 years (2007-09). Since hog prices should reflect onfarm costs of production, farmgate prices would be expected to increase in the absence of productivity gains.

Figure 13 also shows trends in U.S. hog and pork prices since 1992 in constant 2005 dollars at the farm, wholesale, and retail levels. The farm value is the gross value of the hog when it is sold, measured in cents per pound of retail-equivalent weight. The wholesale value is the average value of the meat as it leaves the packing plant. The retail value is the average value of selected cuts of meat at the grocery store. While input prices increased, the farmgate price of hogs decreased from 102 cents per pound in 1992-94 to 73 cents in 2007-09, a 28-percent decline. Hence, even though input prices increased (particularly in the last 4 years of the study period), hog prices at the farm level actually declined substantially. The difference between these longrun price trends can be attributed mainly to onfarm productivity increases.

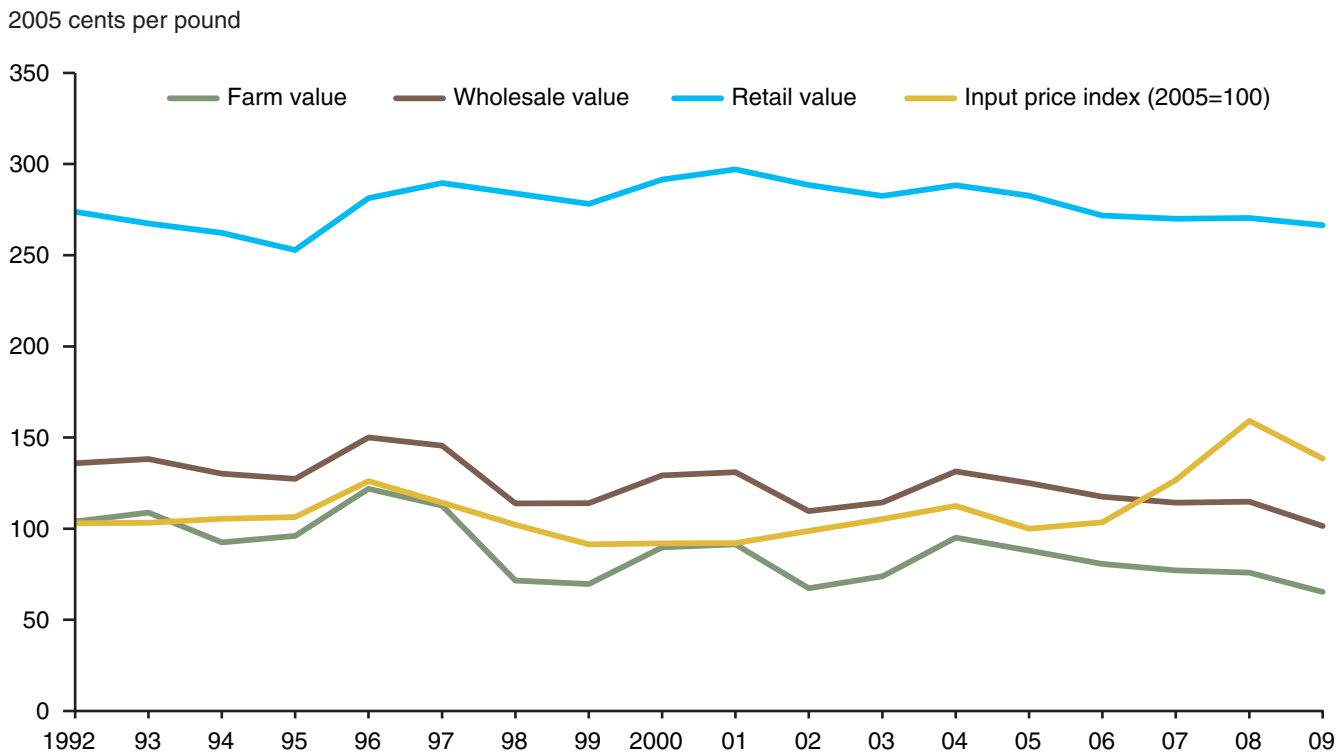
Productivity gains that reduce finished-hog prices do not, however, directly translate into lower retail prices. While wholesale pork prices (at the packing house) show a very similar trend to farmgate prices, retail pork prices remained essentially flat over 1992-2009. Retail prices did not decline

²⁸Weights are the average cost share for these inputs for finished hog producers in the 1992, 1998, 2004, and 2009 surveys.

Figure 13

Trends in real U.S. live hog, pork, and input prices, 1992 to 2009

Relationships between hog, pork, and input prices suggest that increased hog farm productivity during 1992 and 2009 helped to hold down pork prices for consumers.



Source: USDA Economic Research Service calculations using data from the Bureau of Labor Statistics, the Census, and USDA Agricultural Marketing Service.

in part because the cost of hogs comprises only about a third of the total cost of retail pork (hogs must be slaughtered and processed, and pork must be transported and marketed).²⁹ Hence, the productivity and market structure of the processing and retail sectors are important determinants of retail pork prices. Factors that may have contributed to the increasing spread between retail and farm prices include slower productivity growth in the retail sector, greater input price inflation for retailers, and increasing value added (see Hahn (2004) for more information about meat price spreads). Nonetheless, even though real retail pork prices did not fall over 1992-2009, prices would likely have been higher had gains in hog farm productivity not helped hold hog prices down at the farm level.

Increasing Exports

Higher productivity and lower production costs enhance the competitive advantage of U.S. pork producers. Lower production costs allow U.S. producers to increase their market share overseas and to remain competitive with importers. U.S. pork products are exported primarily to Japan, Mexico, and Canada, while the majority of U.S. imports come from Canada (USDA-ERS, 2012). In 2008,

²⁹The share of the farm value of pork (net byproducts) in the retail value has fluctuated between 23 and 43 percent between 1992 and 2009, and averaged 32 percent (see <http://www.ers.usda.gov/data-products/meat-price-spreads.aspx>).

the United States accounted for 39 percent of world exports, followed by the European Union (25 percent) and Canada (17 percent).

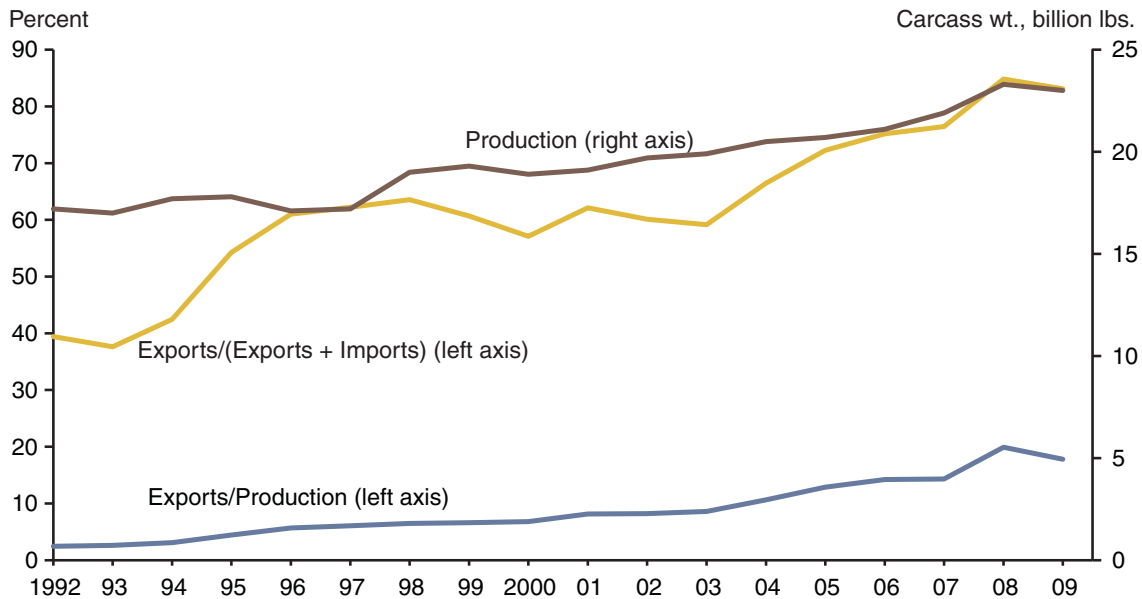
Between 1992 and 2009, U.S. pork production and exports increased substantially (fig. 14). Production increased by about 5.5 billion pounds over this period and much of this increase was driven by exports. Annual exports increased from about 0.5 billion pounds in 1992-94 to 4.0 billion pounds in 2007-09. Exports represented, on average, about 3 percent of production in 1992-94, but about 17 percent of production in 2007-09. Over this period, imports remained flat, so exports as a share of traded goods (imports plus exports) increased from about 40 percent in 1992-94 to 81 percent in 2007-09.

Environmental Risks and Benefits

The shift in the U.S. hog industry to fewer and larger operations that specialize in a single phase of production and that use production contracts has altered manure management, storage, and application practices, with important implications for the environment (Key et al., 2011). The structural changes have meant that an increasing volume of manure is produced on farms having less cropland per animal. Between 1998 and 2009, increases in hog production outpaced growth in crop acreage on which manure was applied, resulting in a 74-percent increase in average manure application intensity.³⁰

Figure 14
Trends in U.S. pork production and trade, 1992 to 2009

U.S. pork exports increased substantially from 1992 to 2009, suggesting that increased productivity enhanced the competitive position of U.S. producers.



Source: USDA Economic Research calculations using data from the U.S. Department of Commerce, Bureau of the Census.

³⁰The application intensity is defined as the farm inventory, adjusted for the removal of manure off the farm, divided by the acres of land on the hog operation on which manure was applied (see Key et al. (2011) for details).

A higher manure-to-cropland ratio can make it more costly for some farmers to apply manure nutrients to land at rates that crops can absorb because operators must transport the manure farther from their facilities (Ribaud, et al. 2003). When too much manure is applied to crops, there is a greater chance that manure nutrients (nitrogen, phosphorus, and potassium) and pathogens will flow into ground and surface water. These runoff contaminants can harm aquatic life and degrade drinking water. In addition, increased concentration of hogs per farm has led to conflicts with nearby residents and communities over odor and air quality. Legislative initiatives, such as the Clean Water Act and various State regulations, have implemented environmental policies to mitigate the risk of water pollution and reduce conflicts.

While the increased concentration of production presents environmental risks, the increase in feed efficiency that has accompanied the structural changes counterbalances these risks to some extent. Nitrogen and phosphorus enter the production system in animal feed. Some of the nutrients are retained in the animal product (meat), but most are excreted in urine and manure (Follett and Hatfield, 2001; ASAE, 2005). Consequently, increases in feed efficiency may have reduced the quantity of nutrients excreted per animal. Since larger operations generally use less feed per hog produced, the increased livestock density on larger operations may be offset by greater feed efficiency.

Other environmental benefits accrue from greater feed efficiency. Higher productivity means that fewer resources—including land, fertilizer, and pesticides—are required to grow the feed required to produce a particular amount of pork. Depending on how the feed inputs are used, this could result in lower greenhouse gas emissions (e.g., from less fertilizer manufacturing and use), reduced water pollution (e.g., from less fertilizer or pesticide over-application), or other environmental benefits. Also, concentrating manure sources in fewer locations potentially affects fewer people and may also make some manure treatment technologies (e.g., energy from bio-waste, or processing into concentrated fertilizer) feasible.

Conclusions

The era of dramatic productivity growth in hog production is likely over, absent new technological innovation. The 1992-2009 data support this conclusion on two fronts. First, the gains from exploiting scale economies are nearly exhausted, as most hog production now takes place at a size where returns to scale are nearly constant. Second, the measurable technological and organizational innovations that contribute to productivity growth (e.g. confinement feeding, production contracts, artificial insemination, all-in/all-out management) are widely diffused. For example, the contribution of contracts to productivity growth may be reaching a limit on feeder-to-finish operations, where 79 percent of hogs were raised under a production contract in 2009. It is likely that other technologies promoting productivity, such as high-performance genetics, are also widely diffused.

Corn and soybean prices can have a significant effect on the structure of hog production. High corn and soybean prices during 2007-09 raised feed costs substantially. Many small operations raise these crops for hog feed, and these relatively high-cost hog producers likely found greater returns from selling crops rather than feeding hogs. As small operations ceased producing hogs, the average size of hog operations—and average productivity—increased further. Contract hog production is conducted on relatively large, lower-cost hog operations. Large contractors, who supply feed to contract grower operations, might be better able to withstand feed cost volatility. However, since 2009, corn and soybean prices increased to record levels and the high feed prices are likely driving additional changes in the structure and productivity of U.S. hog farms.

Glossary

All-in/all-out housing commingles pigs of a similar age and weight and keeps them together as they move through each production phase. Marketing is done a room at a time, and rooms are washed and disinfected between dedicated stages to help decrease the spread of infectious diseases.

Bio-security plans usually specify strict isolation and sanitation programs in order to prevent the advent and spread of disease.

Commercial seed stock producers specialize in the production and sale of high quality breeding hogs.

Contract production is an arrangement between a pig owner (**contractor**) who engages a producer (**grower**) to take custody of the pigs and care for them in the producer's facilities with other inputs often furnished by the pigs' owner. The producer is paid a fee for the service provided.

Farm Resource Regions portray the geographic distribution of U.S. farm production by identifying areas where similar types of farms intersect with areas of similar physiographic, soil, and climatic traits (USDA, ERS).

Hog operations are defined as farms that had a hog inventory of 25 head or more on the acres operated at any time during survey years 1992, 1998, 2004, and 2009. Hog operations include independent hog producers and growers who produce hogs under contract.

Hundredweight gain equals hundredweight of hogs sold or removed under contract less hundredweight of hogs purchased or placed under contract, plus hundredweight of inventory change each year, expressed as:

$$\text{CWTGAIN} = (\text{CWTSR} - \text{CWTPP}) + (\text{CWTEINV} - \text{CWTBINV})$$

Operating costs are the costs for purchased input items that are consumed during one production period. These include feed; feeder pigs; veterinary and medical services; marketing; custom services and supplies; fuel, lubrication, and electricity; repairs; hired labor; and operating capital.

Ownership costs are the costs associated with the ownership of depreciable assets, such as farm tractors and hog-production facilities. These include depreciation, interest, property taxes, and insurance.

Phase feeding feeds hogs or pigs diets of varying protein and energy content at different stages, or phases, of their life to more closely match the diet with their changing nutritional requirements.

Phase of production refers to one of four commonly used categories that describe stages in the hog production process: (1) breeding and gestation—the breeding of females and their maintenance during the gestation period, (2) farrowing—the birth of baby pigs until weaning, (3) nursery—the care of pigs from immediately after weaning until about 30-80 pounds, and (4) growing/finishing—the feeding of hogs from 30-80 pounds to the slaughter weight of 225-300 pounds.

Subtherapeutic antibiotics are antimicrobial drugs fed to hogs at low levels (i.e. levels less than prescribed for therapeutic use) to prevent disease, promote growth, and improve overall animal health.

Terminal crossbreeding programs concentrate on using all possible heterosis of the breeds and thus capitalize on breed strengths. These programs use two-, three-, or four-breed first-cross females that excel in maternal traits bred to boars from breeds that are superior for growth and carcass traits. All the progeny from these matings are marketed and not kept for replacement gilts.

Total economic costs are the full ownership costs (cash and noncash) for being engaged in the enterprise. These include both operating and ownership costs, plus opportunity costs for unpaid labor and land, and costs for general farm overhead items.

Type of hog producer is a classification that defines the hog operation according to the phases of production conducted on the operation and the type of product produced. Some operations in each survey could not be classified using the following criteria:

Farrow-to-finish operations are those on which pigs are farrowed and then finished to a slaughter weight of 225-300 pounds. Using the survey data, these operations were defined as farms on which more than 75 percent of pigs came from onfarm farrowings and more than 75 percent of the value of hogs and pigs left the operation through market hog sales or contract removals.

Farrow-to-feeder pig operations are those on which pigs are farrowed and then sold or removed under contract at or after weaning at a weight of about 30-80 pounds. Using the survey data, these operations were defined as farms on which more than 75 percent of pigs came from onfarm farrowings and more than 75 percent of the value of hogs and pigs left through feeder pig sales or contract removals.

Farrow-to-weanling operations are those on which pigs are farrowed and then sold or removed under contract after an early weaning at a weight of about 10-20 pounds. Using the survey data, these operations were defined as farms on which more than 75 percent of pigs came from onfarm farrowings and more than 75 percent of the value of hogs and pigs left through weanling sales or contract removals.

Feeder pig-to-finish operations are those on which feeder pigs are obtained from outside the operation, either purchased or placed under contract, and then finished to a slaughter weight of 225-300 pounds. Using the survey data, these operations were defined as farms on which more than 75 percent of pigs came from feeder pig purchases or contract placements and more than 75 percent of the value of hogs and pigs left through market hog sales or contract removals.

Weanling-to-feeder pig operations are those on which weanlings (10-20 pounds) are obtained from outside the operation, either purchased or placed under contract, and then fed to a feeder pig weight of about 30-80 pounds. Using the survey data, these operations were defined as farms on which more than 75 percent of pigs came from weanlings purchased or placed under contract and more than 75 percent of the value of hogs and pigs left through feeder pig sales or contract removals.

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