Impacts of Structural Change

Livestock production is shifting to much larger farms. Farms are specializing in stages of livestock production, and contracts are increasingly being used to coordinate the actions of farmers in different stages. These shifts, often quite dramatic, have important impacts. To the extent that scale economies and greater efficiency are driving the shifts to large size and to contract production, then the shifts will lead to improved agricultural productivity—more meat and dairy products for a given commitment of land, labor, and capital resources—and lower wholesale and retail prices for meat and dairy products.

But structural change leads to other impacts as well. Structural changes in farming and processing, toward larger plants and fewer buyers, have occurred in tandem. Larger farms concentrate animals in small areas, heightening pollution risks from excess manure nutrients in land, water, and air resources. Finally, farmers with large herds or flocks in confined areas are more vulnerable to the rapid spread of animal diseases, which they combat with the widespread use of animal antibiotics. This has led to concerns that such widespread use creates human health risks if animal antibiotics accelerate the development of resistance among human pathogens.

Productivity and Prices

Major structural changes often generate large increases in productivity. Increased productivity reduces production costs, leading to lower commodity and retail prices. Productivity improvements also free land, labor, and capital resources that can then be used to produce more of the commodity or of other goods and services.

The broiler industry improved its productivity greatly as its vertically integrated system of production was introduced in the 1950s and then refined through improvements in breeding, feed formulations, housing, and management practices. In 1955, when modern integrated broiler complexes were being introduced (Hart, 2003), it took 73 days to produce the average broiler, which weighed 3.1 pounds, and every 100 pounds of broiler production required 285 pounds of feed and 4 hours of labor. By 1980, it took 52 days to produce a broiler that weighed about 4 pounds, and every 100 pounds of broilers required 208 pounds of feed and 30 minutes of labor (Lasley, 1983).

Because broilers could be produced with less feed, labor, and capital (less time means less capital per broiler), broiler production costs were only slightly higher in 1980 than in 1955, even though prices for production inputs had risen. As a result, retail prices for broilers rose by only 30 percent between 1955 and 1980, while the overall consumer price index for food more than tripled.[19]

Improvement continued after 1980, but at a slower rate. By 2006, it took 49 days to raise the average bird, which weighed 5.4 pounds, and producers used 195 pounds of feed for every 100 pounds of broiler production.[20] With slowing productivity growth, retail chicken prices increased only slightly less than beef or food prices after 1980.[21]

[19] Productivity in broiler production (output per unit of input) rose by 154 percent in this period (or 3.8 percent per year), an exceptionally high rate of growth.

[20] Larger birds take more time to produce, and have higher feed conversion rates. Four- pound birds (comparable to the 1980 average) took 39 days to produce in 2006 and required 188 pounds of feed, or 25 percent less time and 10 percent less feed than 26 years earlier.

[21] Using the relevant Consumer Price Indexes, chicken prices increased by 95 percent between 1980 and 2006, compared to 107 percent for beef and 125 percent for all food.

We have more limited data on cattle productivity, and existing studies use annual industrywide data to analyze the drivers of change in prices paid for feeder cattle. Marsh (2001) measured beef cow productivity over time as annual beef production divided by the Nation's inventory of beef cows (adjusted for imports). Beef production per cow can be increased by raising birth rates of live healthy calves, reducing cow and calf mortality, increasing the mature size of fed cattle, and speeding the time it takes to reach market weight. While the steps to increase birth rates and reduce cow mortality occur in the cow-calf stage, the other routes to boosting productivity may occur in the fed-cattle stage.

Marsh's measure of beef cow productivity increased by 35.5 percent, or 1.6 percent per year, from 1980 to 1999. He attributed the growth to improvements in breeding, animal nutrition, and animal health in both cow-calf operations and feedlots. Productivity growth led to reduced costs and lower feeder cattle prices over the period.

Hog sector structural changes occurred more recently. Key and McBride (2007) compared industry-average production costs for hogs in 1992, 1998, and 2004, with separate estimates for feeder-to-finish and farrow-to-finish operations. As with broilers, industrywide efficiency improvements reduced the amount of inputs needed to produce pork. In the feeder-to-finish sector, average feed conversion rates (pounds of feed required for every cwt of weight gain) fell from 383 pounds in 1992 to 214 pounds in 2004. Labor use (per cwt of weight gain) fell from 53 minutes to 9 minutes. As a result, average production costs fell from $37.54/cwt in 1992 to $26.59/cwt in 2004, despite increases in the prices paid for capital, labor, feed, and other inputs. In real terms (all input prices in 2004 dollars), industrywide average costs dropped by 44 percent between 1992 and 2004.

Key et al. (2008b) estimated that productivity on feeder-to-finish farms grew at an average annual rate of 6.3 percent from 1992 to 2004. When compounded over 12 years, that estimate implies that the amount of hog production that could be realized from a given set of feed, labor, capital, and other inputs more than doubled. Key et al. attributed nearly half of the growth to the realization of scale economies by larger farms and almost all of the remainder to innovations in breeding, feed formulations, and equipment that raised productivity across all farm sizes.

Milk production has benefited from ongoing improvements in breeding, feed formulations, equipment, and management practices, all of which are independent of shifts to larger farms. Still, MacDonald et al. (2007) estimated that industrywide milk production costs were 8 percent lower in 2006 than they would have been had production not shifted to larger and lower cost farms during 2000-2006. The analysis held input prices constant, so the estimated cost declines did not reflect lower prices for inputs, but instead reflected less labor and capital used for a given amount of milk production on larger farms. The calculation captures a short window of time, and the effects over a 10- to 20-year window would likely be commensurately larger.

Structural changes in each livestock commodity have led to substantial cumulative reductions in the resources needed to produce a given amount of meat or milk, and to lower producer and consumer prices. But other consequences have been less felicitous.

Processor Concentration

As farm production shifted to larger operations and tighter vertical linkages, the livestock processing industries became much more concentrated. Most producers now face just a few buyers for their livestock, livestock products, or grower services. While mergers among processors have played a role in increased concentration, the major factor has been increases in plant size which have allowed processing plants to realize scale economies and lower costs (MacDonald et al., 2000; Ollinger et al., 2000). If those lower costs reduced retail prices and led to increased quantities demanded, growers could benefit from increased processor concentration. But increased concentration could also confer market power on processors, enabling them to impose lower prices on growers and higher prices on consumers.

Table 5 summarizes concentration trends among cattle, hog, and broiler processors.[22] The four largest meatpackers held 79 percent of steer and heifer slaughter in 2005, up from 36 percent in 1980, an extraordinary increase that attracted widespread attention.[23] Concentration ratios in cow and bull, hog, and broiler processing have also risen steadily and are substantially higher than in 1985.

National concentration measures understate the concentration that many farmers face in local and regional markets. For example, although feeder animals may move across North America, fed cattle and market hogs rarely move far to slaughter, and feedlots and market hog sellers usually have access to just three or four buyers.

Larger plants allowed packers to realize lower processing costs through economies of scale, with the gains from lower costs passed to consumers and to farm operators (Brester and Marsh, 2001; Ollinger et al., 2000; MacDonald and Ollinger, 2005). However, production is no longer shifting to large processing plants, and there are widespread concerns that packers and integrators may be able to exploit high levels of concentration and reduce the prices that they pay for livestock, livestock products, and grower services.

Highly concentrated local markets for agricultural products aren't new, and some widely used agricultural marketing institutions are designed to limit the exercise of market power and to induce farmers to commit to production in markets with few buyers. For example, farmer-owned cooperatives

[22] The measure, a four-firm concentration ratio, captures the share of livestock or poultry slaughter held by the four largest processors of each commodity.

[23] Steers and heifers are a separate economic market from cows and bulls. Steers and heifers move from feedlots to specialized plants in the Great Plains. Those plants produce different beef products than cow plants, which usually locate in dairy production regions.

Table 5: Concentration in poultry and livestock procurement

	Share of purchases by four largest processors					
Commodity	1980	1985	1990	1995	2000	2005
	Percent					
Cattle						
Steers and heifers	36	50	72	79	82	79
Cows and bulls	10	17	20	23	32	49
Hogs	34	32	40	46	57	64
Broilers	na	34	41	46	49	53

Source: USDA Grain Inspection, Packers and Stockyards Administration (GIPSA), *Assessment of the Livestock and Poultry Industries* (various years).

play a major role in milk handling and processing—70 percent of producers, accounting for 76 percent of milk production, ship their milk to plants operated by their own cooperative.[24]

[24] According to data derived from the 2005 ARMS dairy version.

Many fed cattle are sold to packers in cash markets where prices are determined on a daily and weekly basis. Most smaller producers, and most small packers, use cash markets exclusively, while large producers and packers use a variety of marketing channels (RTI, 2007a). The market is characterized by high buyer concentration, and by several features of bidding that would seem to discourage aggressive competition among packers (MacDonald, 2006; Xia and Sexton, 2004).

Because of its size, high concentration, and readily available data, there are many studies of competition and pricing in the fed-cattle industry. Some find that prices look like those that would prevail in competitive markets—that is, they find no evidence of packer market power (Morrison-Paul, 2001). Others find that prices are below those that would prevail in competitive markets—that is, they find evidence of monopsony on the part of packers—but the estimated effects on prices are small (Azzam, 1997). Despite high concentration and bidding practices that might facilitate the exercise of market power, the studies find little evidence of extensive market power in fed-cattle (Koontz, 2003). However, increases in concentration from current levels could provide packers with the power to force cattle prices down. In markets with only three or four buyers, mergers among buyers will attract close scrutiny, particularly where there are no apparent offsetting efficiency gains.[25]

[25] These issues lie at the heart of the U.S. Justice Department's recent court filing opposing the proposed acquisition of National Beef Packing, the 4th largest beef packer, by JBS-Swift, the 3rd largest packer. See www.usdoj.gov/atr/cases/f238300/238388.htm

Growers of broilers, and growers of hogs under production contracts, operate in a different environment. They do not sell livestock in commodity markets, but instead are hired to grow for an integrator who links stages in a production complex that covers just a few counties. The competitive issues in these businesses, therefore, refer to labor markets for grower services and not to product markets for livestock. While hog growers tend to have three or more integrators operating in their area, sometimes with cash market alternatives, broiler growers are likely to have only one or two integrators, with no cash market outlets (MacDonald and Korb, 2008).

In markets for grower services, potential hog or broiler growers have choices—they can invest their time or money in other agricultural commodities, or in nonfarm employment—and integrators must compete with those activities to attract growers. Production contracts commit the integrator to provide chicks or pigs, and commit the integrator to a compensation agreement--contracts therefore offer more assurance to growers than they would get in a highly concentrated cash market, where no such assurances exist.

The competitive risk to contract growers arises after they have made a substantial capital investment in housing, when the initial contract expires. Many production contracts are short term, as little as the 35-45 days it takes to grow a flock, even though the grower makes a long-term financial commitment. At that point, an integrator may be able to impose extra costs or lower payments on a grower as a condition of contract renewal. However, an integrator that develops a reputation for exploiting growers will have difficulty attracting new growers. And growers—especially hog producers who have more options—may contract with other integrators or shift to cash markets.

Spot Markets and Marketing Information

Spot market transactions provide benefits to all market users because transaction terms—including prices, locations, and observable quality characteristics—are readily available and easy to record. Accurate and widely available market information helps speed the discovery of a “market price” through arbitrage, as buyers try to avoid paying unnecessarily high prices and sellers try to avoid accepting unnecessarily low prices. Visible, accurate, and reliable market price information should provide important signals such as value differences, regional price differences, and quantities available to buyers and sellers. In turn, those signals should guide production decisions, giving producers incentives to produce what buyers want.

USDA collects information from market transactions in the livestock and grain industries, and provides regular reporting of prices, quantities, and transaction characteristics in its *Market News* program. Traditionally, *Market News* reporters collected information firsthand at major auction markets, and by telephone from producers, processors, retailers, distributors, and brokers. Reports were available to all interested parties, and were widely used in the trade. Some *Market News* reports were highly localized, detailing quantities and prices received during a narrow time period at an auction market. Other more aggregated reports summarized terms across a wide geographic area for a week, month, or year.

As transactions, particularly in the hog and fed-cattle sectors, shifted away from spot markets and toward contractual relationships, the amount and quality of information available for *Market News* declined (Perry et al., 2005). Participants in contract sales frequently did not provide information to reporters, reducing the amount of information available. In addition, to the extent that contract purchases covered animals with different qualities than those traded in spot markets, public reporting might no longer be representative of the market. This development is of concern to all market participants, and not just those in the spot market, because many prices in many contracts are based on reported market prices.[26]

[26] Tighter coordination, through contracts or vertical integration, may provide producers with better incentives to deliver animals of higher or more consistent quality. That is, the growth of contracts can result from deficiencies in the effectiveness of existing spot market reporting.

In response to these concerns, Congress passed The Livestock Mandatory Reporting Act of 1999 which requires the reporting of all livestock sales transactions of large meatpackers. The Act established a program of reporting information regarding the marketing of cattle, swine, lambs, and products of such livestock. This program provides information on pricing, contracting for purchase, formulated sales, and supply and demand conditions for livestock, livestock production, and livestock products that can be readily understood by producers, packers, and other market participants.

Environmental Impacts

The livestock industry also produces wastes in the form of manure, urine, and bedding material. Manure contains organic material and nutrients for crop and pasture growth, but animal wastes can also despoil water and air resources and compromise their commercial and recreational uses. Wastes can be transmitted to surface water through the runoff of nutrients, organic matter, and pathogens from fields and storage; to ground water through the leaching of nutrients and pathogens; and to the atmosphere through the volatilization of gases and odors. Pollutants may originate at structures where animals are kept; at manure storage facilities such as tanks, ponds, or lagoons; or on land where manure is stored or is applied as fertilizer.

Industrialized production concentrates manure on limited land areas. Consequently, some producers apply manure to their land at intensities well above the agronomic needs of their crops, thereby increasing pollution risks. Others may need to remove manure to be spread on cropland at other operations. We detail the basic links between farm size, manure production and management practices, and land use in table 6, using data from the ARMS hog (2004), dairy (2005), and broiler (2006) versions.

For comparison purposes, the farm size classes in table 6 are defined according to onfarm inventories of animal units (AU)—1,000 pounds (liveweight) of livestock or poultry.[27] There are significant differences between broiler operations and the other two commodities, so we discuss them separately.

Farmers can apply manure to their own fields, remove it for application on other farms, or remove it for processing.[28] About 5 percent of dairy farms and 10 percent of hog farms, accounting for 12 and 19 percent of production, have no cropland and must therefore remove all of their manure (table 6). But farms with cropland also remove manure, especially if the cropland is far from manure storage facilities.[29] In total, 19 percent of the manure on dairy farms, and 26 percent of that on hog farms, is removed. The share of manure that's removed rises quite sharply with farm size, which suggests that many large farms have insufficient land for manure application.

Large operations that apply manure typically have a lot of cropland—over 1,000 acres, on average, at the largest dairy and hog farms (table 6). But manure is usually applied to only a fraction of the farm's cropland, a pattern also apparent in the 1998 hog and 2000 dairy ARMS data (Ribaudo et al., 2003). Large farms often operate some cropland at considerable distances from manure storage facilities, and may produce some crops with limited nutrient needs.

Manure application intensities—the number of animal units per acre of land receiving manure—largely determine the amount of manure applied per acre. This measure rises quite sharply with farm size.[30] The largest dairy farms have more than three times as many animal units per acre as farms in the smallest class, and the largest hog farms have six times as many as the smallest hog farms (table 6).

Waste management practices on broiler operations differ in some important respects. A third of broiler farms have no cropland, and 60 percent of broiler litter is removed. Most farms that apply manure apply it to all of their land (manure may be applied to pastureland, which is why acres applied exceeds total cropland in several size classes in table 6). But farm size still matters. Larger broiler operations are more likely to remove all of their manure, and larger operations have higher land application rates.

Large livestock operations store substantial quantities of manure onsite. The manure is generally applied to cropland much more intensely than on smaller farms, and large volumes of manure must still be removed from the

[27] For conversion to AUs, mature dairy cows and bulls were assumed to weigh 1,350 pounds and breeding swine were assumed to weigh 375 pounds. Livestock destined for slaughter only reach market weight when they leave the farm, so we had to estimate average onfarm weights. Broilers were set at half of the average weight at removal reported for the farm, while market hogs were assumed to weigh the average of their market weight and their weight when entering the farm's inventory.

[28] A few farms incinerate or process manure onsite, but almost all manure that stays on the farm is applied to fields.

[29] A farm's cropland isn't necessarily contiguous. If some parcels are miles away from livestock operations, removal to another farm's nearby cropland could be economic.

[30] We reduced estimated inventories of animal units by the share of manure removed from the farm, and then divided the adjusted inventories by the amount of acres receiving manure.

Table 6: Manure management on dairy, hog, and broiler operations, 2004-06

Commodity and size class	All farms: Percent with no cropland	All farms: Manure removed (percent)	Farms that apply manure to fields: Average cropland acres	Farms that apply manure to fields: Acres with manure applied	Farms that apply manure to fields: Animal units per acre
Dairy					
Across farms	5	5	305	156	1.6
Across production	12	19	720	484	2.6
By size class (AU)					
<300	3	3	255	117	1.4
300-649	12	12	561	327	2.5
650-999	12	23	822	591	3.1
1,000-1,999	22	37	1264	844	3.3
2,000 or more	26	49	1500	1091	4.8
Hogs (market)					
Across farms	10	16	599	97	3.5
Across production	19	26	922	228	8.4
By size class (AU)					
<300	7	13	536	63	1.9
300-649	10	20	722	168	5.7
650-999	14	29	718	197	7.0
1,000 or more	27	33	975	261	13.5
Broilers					
Across farms	32	58	133	131	2.1
Across production	29	60	185	177	2.3
By size class (AU)					
<300	33	56	105	105	1.9
300-649	30	63	169	172	2.6
650-999	28	63	223	268	2.7
1,000 or more	9	68	598	335	3.0

Notes: One animal unit equals 1,000 pounds (liveweight) of livestock or poultry in inventory. Average liveweight of animals in inventory was assumed to be 1,350 pounds for cows and bulls; 375 pounds for breeding swine; for slaughter swine, one-half of the difference between market weight and weight when entering the farm's inventory; and half of the average weight at removal for broilers.

Source: Authors' calculations, based on data from the Agricultural Resource Management Survey, version 4, 2004 (hogs), 2005 (dairy), and 2006 (broilers).

operation. High concentrations of manure—whether stored in lagoons, pits, or ponds prior to transport or application—raise the likelihood of leaching or volatilization, threatening groundwater and air quality. And farms that intensively apply manure to cropland and pasture may apply it at rates that exceed the ability of crops to absorb nutrients, with the excess nutrients transmitted to water and air resources. Analysis of pollution risks from manure must therefore consider nutrient loadings and uses.

Gollehon et al. (2001) used confidential farm-level data from the census of agriculture to estimate the production of manure nutrients, and excess manure nutrients, between 1982 and 1997. Specifically, the census collects farm-level information on animal inventories, by type of animal, and acreage by type of use (farmland and cropland, by crop). Gollehon et al. combined the animal inventory data with estimates of annual manure and nutrient production by animal type to estimate nitrogen and phosphorus quantities produced on each farm. They then combined data on nutrient uptake by crop to estimate the amount of manure-based nutrients that could be used by onfarm crops. The difference between nutrient production and potential nutrient use provides an estimate of excess nutrient production on a farm.

Some farms in all size classes produced enough manure-based nutrients to exceed the farm's potential assimilative capacity.[31] However, the largest livestock and poultry operations were most likely to produce excess nutrients, and they accounted for a preponderant share of total excess nutrient production at the farm level. Excess nutrient production increased substantially between 1982 and 1997 and it increased in every region, especially those with high concentrations of large livestock and poultry operations.[32]

Manure can be moved from one farm to another for application, but high transportation costs limit the practical distance manure can travel. Gollehon et al. found that, in 1997, crop nutrient needs in most counties were high enough to use all available manure-based nutrients. However, about 5 percent of counties did not have crop needs sufficient to use all the available manure-based phosphorus produced in the county (the corresponding figure for nitrogen was 2 percent). Those counties tended to be centers of industrialized livestock production.

Regulation of Manure Practices

Federal, State, and local governments have responded to the environmental problems posed by livestock operations with regulations and conservation programs. The U.S. Environmental Protection Agency introduced Clean Water Act regulations in 2003 for controlling runoff of manure nutrients from the largest animal feeding operations. Farms designated as CAFOs must develop and implement a nutrient management plan that bases nutrient applications on agronomic rates, a provision that requires many CAFOs to spread their manure over a much larger land base than they are currently using. Most will need to move manure off-farm.[33]

Many States have also enacted regulations that address environmental issues, including some not addressed at the Federal level. Some had manure application restrictions in place prior to EPA's 2003 regulations, some of which extended to smaller operations. Odor is a persistent local issue, and many States are using setback requirements to separate animal operations from residential areas. Ammonia emissions from large animal feeding operations have prompted California to enact regulations in the San Joaquin Valley to protect heavily populated areas downwind. North Carolina imposed a partial moratorium in 1997 on the construction of new hog farms in the State, in response to widespread concerns over waste management.

Because of expanding State and Federal regulations, certified nutrient management plans (CNMPs) are coming into widespread use. According to 2004-2006 ARMS data, 62 percent of U.S. hogs, 60 percent of broilers, and 49 percent of dairy cows are on operations that have CNMPs.[34] The intensity of nutrient applications will need to be reduced to comply with many of the plans, with several paths to compliance. More cropland acres for manure application may be found by applying manure to more of the farm's cropland, acquiring more cropland, or removing manure from the farm and

[31] The estimates are conservative, because Gollehon et al. did not take into account the additional nutrients that farms could apply in commercial fertilizers.

[32] These include the hog and poultry production region stretching from eastern North Carolina through north Georgia and Alabama; the fed-cattle production region covering eastern Colorado, southwestern Kansas, and the Texas and Oklahoma Panhandles; and the dairy production regions of central and southern California.

[33] Some AFOs that are not defined as CAFOs must also implement nutrient management plans in order to be covered under the stormwater exemption of the Clean Water Act. The 2003 regulations were the subject of continuing litigation, which barred implementation. EPA issued a final rule on October 31, 2008.

[34] In 2004 (hogs), 2005 (dairy), and 2006 (broilers). Correspondingly, 30 percent of hog farms, 32 percent of dairy farms, and 60 percent of broiler farms had a CNMP. The plans cover larger shares of animals than of farms because larger farms are more likely to be required to have one.

applying it to crops on other farms. The amount of manure nutrients associated with animal production can be reduced by changing feed formulations or altering breeding to improve feed efficiencies. Stages of animal production can be moved nearer to locations with sufficient cropland. Finally, manure may be treated to reduce transportation costs, enabling it to travel farther and to be used as a feedstock for energy generation and manufacturing.

Ribaudo et al. (2003) evaluated the potential impacts of compliance with environmental regulation, with a focus on the first option—reducing intensity by expanding acreage. They found that most CAFOs would need a much larger land base for manure application than they were currently using, or that they would need to remove much more manure from their operations. In turn, the effect of manure removal on the source farms' financial performance depended on the willingness of nearby crop farms to accept manure. Commercial fertilizers are often preferred to manure because they are easier to apply and because they can be formulated to contain the precise combinations of nutrients needed for particular applications. However, manure fertilizers may be acceptable, at the right price.

There's little empirical evidence on the willingness to accept manure (WTAM) among crop producers, so Ribaudo et al. modeled the costs of compliance for WTAM ranging from 10 percent to 80 percent of farms. Costs of removal will also vary across regions, depending on the available cropland and manure production, and across farm sizes, since larger farms will generally need to remove more manure to comply.

Manure removal would raise total production costs for dairy and hog operations, and would raise them by more on large farms. But the estimated cost increases were modest. With a 20-percent WTAM, Ribaudo et al. estimated that compliance would raise hog production costs on the largest operations (1,000 or more animal units) 1-3 percent, compared to 1 percent or less on small operations. Production costs on the largest dairy operations (also 1,000 or more animal units) would increase an estimated 2-3 percent, compared to 1 percent on small operations. If nearby farmers were less willing to accept manure, large operations would face higher costs, up to 5 percent in some regions. Nevertheless, a cost increase of this magnitude is more than offset by the production cost advantages of large operations (figures 6-8), so it is unlikely that farm structure would be altered by compliance costs that fall in the range reported in Ribaudo et al.

Much manure is currently removed from operations—about 19, 26, and 61 percent of dairy, hog, and broiler manure (table 6). Some is sold, and some is removed for a fee, but most is given away (table 7).

Even when farmers pay to have manure removed, the cost of removal was not prohibitive. Among those dairy farms that removed manure in 2005, fees added 39 cents per cwt to the cost of production, or 3 percent of production costs at the largest farms (fig. 6). Similarly, fees paid for manure removal by hog producers in 2004 amounted to 34 cents for every cwt of weight gain, or 1.4 percent of the average cost of production on large finishing operations (fig. 7). Broiler farms that paid for litter removal incurred fees amounting to 0.3 cent per pound of meat produced, or less than 1 percent of the cost of production.[35] Livestock farms will likely have to remove more manure under

[35] The hog and broiler costs of production are total costs, including those borne by integrators as well as those borne by growers. Manure removal fees account for about 6 percent of the contract payments received by growers.

Table 7: Manure removal from livestock operations, 2004-06

	Dairy	Hogs	Broiler
	Percent of total production		
Manure removed from operation	19	26	61
--Sold by operation	4	5	22
--Operation paid to haul it away	7	3	3
--Operation gave it away	8	18	36
	$ per cwt of production		
Prices			
Revenue from manure sales	0.28	0.22	0.20
Expenses to haul manure away	0.39	0.34	0.31

Source: Authors' calculations, based on data from the Agricultural Resource Management Survey, version 4, 2004 (hogs), 2005 (dairy), and 2006 (broilers).

CNMPs in the future. As removals increase, more producers will likely have to pay to have manure removed, and removal fees will likely rise. However, those fees would have to increase five- to ten-fold to offset the current production cost advantages held by large operations.

Manure transport is not the only option for reducing nutrient loadings. There is evidence that the amount of manure and nutrients associated with a given amount of livestock production can be reduced, and that CNMPs may be driving some reductions. Key et al. (2008a) use ARMS hog data to investigate two options. First, they find a substantial increase, between 1998 and 2004, in the use of microbial phytase, which is used as a feed additive to reduce the amount of phosphorus excreted in manure. Phytase use in feeding helps producers manage phosphorus levels in manure to comply with phosphorus-based nutrient management plans. In 1998, 4 percent of hog producers, accounting for 12 percent of production, added phytase to their feed. By 2004, 13 percent of producers, accounting for 30 percent of production, were doing so.[36] Second, improvements in breeding and in feed formulations have led to a substantial decline in the amount of feed used to produce pork; between 1998 and 2004, the amount of feed used to produce 100 pounds of pork fell from 282 pounds to 214 pounds, a 24-percent decline. Since feed that is not converted to meat is excreted, this implies a 24-percent decline in the quantity of nutrients excreted per animal produced, assuming the nutrient composition of feed and meat has not changed substantially over this period.[37]

Antibiotic Use and Health-Related Impacts

Livestock producers take a variety of steps to prevent the emergence and spread of animal diseases among their herds and flocks. Practices include pathogen testing, vaccinations, provision of antibiotics, segregation of herds or flocks by age, sanitary protocols in housing units, and physical biosecurity measures. Antibiotics are used to treat sick animals, but they are also administered in subtherapeutic doses, usually in water or feed, to protect animals against disease and to promote growth. Subtherapeutic antibiotics (STAs) can promote growth, particularly in poultry and hogs, by improving nutrient absorption and by depressing the growth of organisms that compete for nutrients, thereby increasing feed efficiency.

[36] About 27 percent of broiler operations were also adjusting the nutrient content of litter in 2006 by using additives like phytase in feed or directly in litter. Such strategies were less common on dairy operations where 5 percent of farms, accounting for 11 percent of cows, were adjusting the nutrient content of manure through feed additives.

[37] Feed efficiency is positively correlated with the scale of production in the hog sector– larger operations generally use less feed per hog produced.

Many drugs used to treat animals are the same as, or similar to, drugs used for human health care. Consequently, there is concern that the widespread use of antibiotics, especially STAs in animals, could promote development of drug-resistant bacteria that could pass from animals to humans, thus posing a danger to human health. In response to these concerns, the European Union (EU) has banned the use of antimicrobial drugs for growth promotion, and they are coming under growing scrutiny in the United States (U.S. Government Accounting Office, 2008).

Recent ARMS hog and broiler versions have included questions about antibiotic use as well as other health management technologies and practices on farms. The data obtained cannot be used to assess resistance and health hazards, but they can be used to identify the extent of STA use on livestock operations, the impacts of STAs on costs and productivity at different types of operations, and alternatives to STAs for disease prevention and growth promotion.

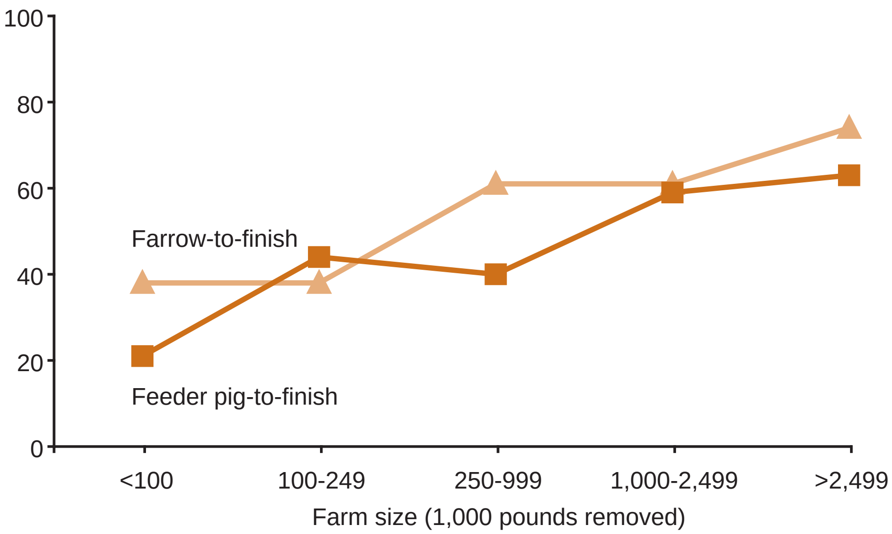
In the ARMS 2004 hog version, producers were asked whether they provided antibiotics, the purpose for provision (growth promotion, disease prevention, or disease treatment), and the types of animals receiving the drugs (breeding animals, nursery pigs, or finishing hogs). Antibiotics were used most widely on nursery pigs in specialized wean-to-feeder operations (McBride et al., 2008). Eighty percent of the surveyed farms used antibiotics for disease treatment, and 85 percent provided STAs for either disease prevention or growth promotion.

Among farms that finish hogs, STAs are widely provided for growth promotion, and larger operations are considerably more likely to provide them (fig. 9). About 20 percent of small feeder-to-finish operations provided their animals with growth-promoting STAs in 2004, compared to 60 percent of the largest operations. Farrow-to-finish operations are generally more likely to provide STAs—nearly 40 percent of smaller operations and 75 percent of the largest.[38]

[38] Similar patterns hold for STAs provided for disease prevention: the smallest class of producers are less likely to use them than the largest, where 65-75 percent of producers use them.

Figure 9
Larger hog farms are more likely to use growth-promoting subtherapeutic antibiotics

Percent of farms using growth-promoting subtherapeutic antibiotics



Source: 2004 Agricultural Resource Management Survey, Version 4.

STAs add to farm expenses, but can also add to productivity by increasing the amount of meat that can be produced from a given combination of breeding animals, feed, and time. This productivity impact likely varies over time and across operations, depending on factors such as animal genetics, feed formulations, production practices, housing features, and management skills.

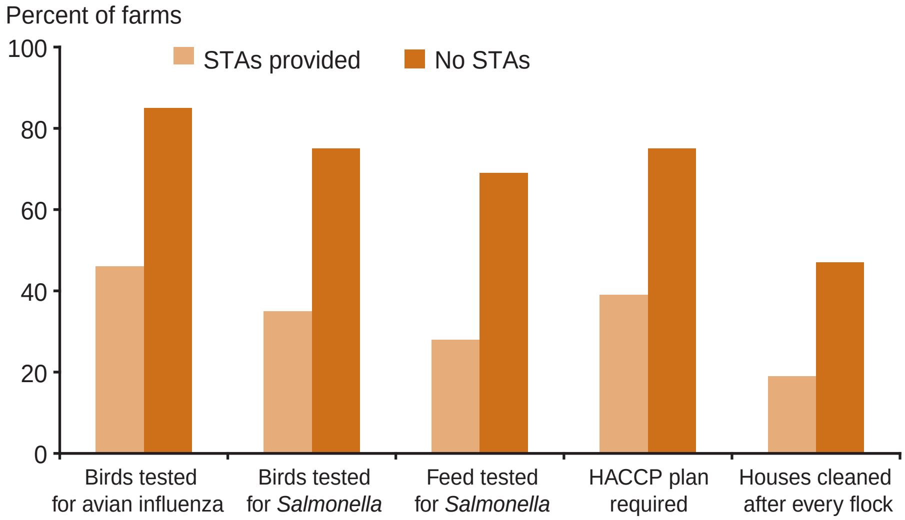
McBride et al. (2008a) investigated which hog farms provided STAs and the effects of provision on farm-level productivity. The provision of STAs seemed to reduce costs at the nursery stage: operations that did not use STAs at the nursery stage had costs that were 30 percent higher than those that did (in a model with controls for the size of the operation, its location, and a variety of production practices). This evidence suggests that STAs reduce mortality and improve feed efficiency among nursery pigs.

In contrast, McBride et al. found little impact of STAs on production costs at the finishing stage—farms that used STAs had costs of production that differed little from those that did not. Any productivity improvement from STAs was not large enough to offset the additional expenses, suggesting the viability of alternative practices or technologies to reduce disease or improve feed efficiency at finishing stages. These results are consistent with studies of the EU ban on STAs, which also suggest that farm-level benefits vary across stages of production and are most pronounced in the nursery stage.

A study of STAs in broiler grow-out operations provided evidence consistent with the findings for hogs. Graham et al. (2007) evaluated the results of a large nonrandomized control trial run by one large integrator in which growth-promoting STAs were removed from some broiler houses, whose flocks' performance was then compared to flocks from houses on the same farm that continued to use STAs. STAs boosted feed efficiency slightly, but not enough to offset the expense, so non-STA houses performed slightly better financially.

Producers and integrators may be able to substitute other practices and technologies for STAs in broiler production. In the 2006 ARMS broiler version, 42 percent of respondents stated that STAs were not provided to their flocks. In contrast to hog finishing operations, there was no relation between farm size and the use of STAs in broiler grow-out (virtually all broiler grow-out farms are contract operations, so it might be argued that all broiler production is industrialized). Farms not providing STAs instead used extensive testing and expanded sanitation controls (fig. 10). Specifically, farms that did not provide STAs usually tested their birds (for avian influenza, salmonella, and other pathogens), and their feed (for salmonella), while farms that relied on STAs were much less likely to test. Farms that did not provide STAs were also much more likely to fully clean out and sanitize their houses after every flock, and typically were required to have a HACCP (Hazard Analysis and Critical Control Point) plan in place to guide food safety actions.

Figure 10
Testing and sanitation substitute for subtherapeutic antibiotics (STAs) in broiler production



Source: 2006 Agricultural Resource Management Survey, Version 4.