Improvements in Hog Farm Productivity: Causes and Consequences

Substantial increases in hog farm productivity have coincided with the industry's pronounced structural changes. Farm productivity can be measured as the average quantity of inputs used in production per unit of output. ARMS collected detailed information about hog production, including inputs and output. This analysis measures output in terms of *hog weight gain*—the weight added during the prior calendar year to 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 removed," accounts for changes in inventory and for differences in the weights of feeder and finished pigs across operations.[3] ARMS asked farmers about changes in their hog inventory and about the quantity and weights of hogs moved on and off the farm. The survey also asked farmers about the amount and types of feed purchased by the operation or contractor, the amount of homegrown feed used, and the number of hours of labor spent on the hog enterprise (including time by the operator and paid and unpaid labor).

The average quantity of feed required per hundredweight of gain declined 14.9 percent (1.3 percent average annual decline) for farrow-to-finish operations between 1992 and 2004 and declined 44.1 percent (4.7 percent annually) for feeder-to-finish operations (table 4). 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 falling 83.1 percent (13.8 percent annually) for feeder-to-finish operations.

Productivity gains contributed to a decline in production costs between 1992 and 2004. For all farrow-to-finish hog producers, average production costs per hundredweight of gain, expressed in 2004 dollars, were 27.9 percent lower in 2004 than in 1992. This change amounts to a 2.7-percent average annual rate

[3]Each head produced represents approximately a 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 removes 3,000 head per year. Assuming three hog cycles per year, annual production of 6,000 cwt implies an operation has an inventory of 1,000 head.

Table 4
Efficiency and production costs per cwt by type of hog producer

Item	1992	1998	2004
Farrow-to-finish			
Feed conversion rate (lbs per cwt gain)	416	374	354
Labor rate (hrs per cwt gain)	1.13	0.72	0.54
Production costs, current dollars[1]	46.63	43.50	42.44
Production costs, 2004 dollars[1]	58.89	49.20	42.44
Feeder-to-finish			
Feed conversion rate (lbs per cwt gain)	383	282	214
Labor rate (hrs per cwt gain)	0.89	0.24	0.15
Production costs, current dollars[1]	37.54	31.08	26.59
Production costs, 2004 dollars[1]	47.41	35.15	26.59

[1]Production costs are the sum of operating and capital costs less costs for feeder and nursery pigs. Pig costs are excluded because they are not an input contributing to weight gain. 1992 and 1998 costs are deflated to 2004 dollars using the national GDP implicit price deflator (Bureau of Economic Analysis).

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

of decline. Real costs declined faster for feeder-to-finish hog producers, falling 43.9 percent between 1992 and 2004, or 4.7 percent annually.

Sources of Productivity Growth

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 may be 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 at the expense of independent production. The organizational structure of the industry also reflects efficiency gains from increased specialization of the various phases of hog production on separate operations.

Given output and input prices, the total factor productivity (TFP) of the farm determines returns. TFP is the quantity of farm output per unit of inputs (with all inputs aggregated). TFP reflects the production technology available (which determines the rate at which inputs can be combined to make outputs), whether farms are operating at an efficient scale of production, how efficiently inputs are combined given the production technology, 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 feed 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 all inputs.[4] The movement toward the optimal scale of production (the scale at which the scale elasticity equals one) is said to increase *scale efficiency.*

Table 5 suggests increasing returns to scale in each survey year—per unit production costs decline as the scale of production increases.[5] It seems likely that some of the decrease in average unit costs shown in table 4 has resulted from the growth in the size of operations. That is, between 1992 and 2004, 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.

While increases in scale efficiency and technological change are likely the largest sources of productivity growth, farms also may become more

[4]For 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. Scale elasticity equal to 1 implies constant returns to scale—that is, there is no productivity gain (or loss) from increasing the scale of production. Scale elasticity below 1 implies decreasing returns to scale—efficiency would actually decline if production were increased.

[5]Increasing returns to scale are usually associated with declining per unit costs as output increases. However, declining per unit costs do not always imply increasing returns to scale. Lower per unit costs for large producers may also result if technical efficiency or allocative efficiency increases with scale, or if input costs decrease with scale. In addition, it is not necessarily the case that all inputs increased proportionately as scale increased.

Table 5
Production costs per cwt by type and size of hog producer

Item	1992	1998	2004
		Dollars per cwt gain	
Farrow-to-finish			
Cwt gain<1,000	72.38	78.39	73.55
1,000≤cwt gain< 2,500	63.26	57.70	51.29
2,500≤cwt gain<10,000	54.88	46.91	39.94
10,000≤cwt gain<25,000	54.12	39.35	37.52
25,000≤cwt gain	id	38.61	36.03
Feeder-to-finish			
Cwt gain<1,000	61.99	57.49	45.46
1,000≤cwt gain< 2,500	46.07	48.02	33.34
2,500≤cwt gain<10,000	43.70	36.03	31.03
10,000≤cwt gain<25,000	id	26.97	23.03
25,000≤cwt gain	id	26.26	24.06

Note: Production costs are the sum of operating and capital costs less costs for feeder and nursery pigs. Pig costs are excluded because they are not an input contributing to weight gain. 1992 and 1998 costs are deflated to 2004 dollars using the national GDP implicit price deflator (Bureau of Economic Analysis).
id = insufficient data for legal disclosure.

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

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 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 the mix of inputs to better reflect their relative costs. 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).

This study focuses on measuring and understanding changes in *farm-level* total factor productivity. It uses ARMS data to disaggregate changes in farm TFP into changes in four constituent parts: technical change, technical efficiency, scale efficiency, and allocative efficiency. Productivity gains at the industry level have accompanied substantial farm-level productivity gains. Industry-level efficiency gains result in part from increasing specialization in the various stages of hog production. As discussed in the previous chapter, the hog industry has seen finished hog production move from one to two or three separate operations. That is, since 1992, the share of hog output produced by farrow-to-finish operations has declined, while the share of output produced by feeder-to-finish operations has increased. Feeder-to-finish operations obtain feeder pigs from separate operations that raise feeder pigs (farrow-to-feeder or farrow-to-wean and wean-to-feeder). As production shifted from less efficient farrow-to-finish operations to more efficient specialized operations, the total costs of producing finished hogs industrywide may have declined substantially, resulting in industry-wide improvements in productivity. This study does not assess industrywide efficiency gains from changes in specialization.[6] Instead, it examines productivity growth at one important stage of hog production—feeder-to-finish —which now accounts for most finished hog output (having increased from 22 percent to 77 percent of all output between 1992 and 2004 (see table 1).[7] Feeder-to-finish operations make an interesting case study because their large and increasing share of output suggests these farms will dominate the industry in the future, and they have had the fastest productivity growth since 1992 (see table 4) and the greatest increase in scale of production (see table 1).

[6]ARMS did not survey enough farrow-to-wean or wean-to-feeder pig operations in 1992 and 1998 to measure industry-wide efficiency gains from increased specialization.

[7]Feeder-to-finish operations are those on which feeder pigs (weighing 30-80 pounds) are purchased/placed, finished, and then sold/removed for slaughter (weighing 225-300 pounds).

Disaggregating Productivity Growth

Disaggregating the observed increases in total factor productivity into technical change, technical efficiency change, scale efficiency change, and allocative efficiency change provides insights into the forces that drive structural change. The methodology used here to disaggregate TFP follows Orea (2002) and is described in more detail in the appendix. The approach requires estimation of a production frontier—a parametric relationship 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).

Economists calculate an index of technical efficiency as a farm’s ratio of observed output to what could be produced with the same inputs if the farm operated on the estimated production frontier. If the same farm could be observed over time, changes could be tracked in this index (a measure of technical efficiency). However, because ARMS is a repeated cross-section rather than a panel, the study estimates technical efficiency change for a representative (average) farm.

The estimation method permits the parameters of the production frontier to vary over time to allow for technical change. Technical change measures output changes resulting from changes in production technology, holding efficiency, scale, and prices constant. Scale efficiency change captures TFP changes caused solely by changes in input levels, holding technical efficiency, the production function, and prices constant.

Allocative efficiency change measures TFP changes resulting from changes in the “cost effectiveness” of inputs. Relative to their contributions to output, some inputs may be relatively “expensive,” and others may be relatively “cheap.” Allocative efficiency improves when a firm uses more of the relatively inexpensive inputs, and less of the relatively expensive inputs. TFP is an index of output produced per unit of inputs, where inputs are aggregated into an index using prices as weights. Allocative efficiency change is the residual difference between the total change in TFP (which depends on prices) and the change in the TFP explained by changes in production technology, efficiency, and scale (changes that do not depend on prices).

By definition, the percentage change in TFP equals the sum of technical change plus changes in technical efficiency, scale efficiency, and allocative efficiency. For all farms, TFP more than doubled between 1992 and 2004, with an average increase of 6.3 percent per year (table 6). This is a very high rate of growth—about three times the historical growth rate in productivity for the agricultural sector as a whole (Ahearn et al., 1998). Average annual TFP growth rates were similar in both periods between the ARMS surveys—with average increases of 6.4 percent from 1992 to 1998 and 6.3 percent from 1998 to 2004.

Technological change and increases in scale efficiency accounted for most of the growth in TFP (increasing 3.0 percent and 3.4 percent annually, respectively). The contribution of technological change to productivity growth increased substantially in the second period—from 2.1 percent annually between 1992 and 1998 to 3.9 percent annually between 1998 and 2004. In contrast, the scale effect diminished over time: scale efficiency increased 4.5 percent annually between 1992 and 1998 but only 2.2 percent between 1998 and 2004.

Average technical efficiency changed little over the 12-year study period. Allocative efficiency change also played a small role in TFP change—increasing at an annual rate of 0.5 percent.

Implications for Scale of Production

Increases in scale efficiency contributed significantly to productivity gains between 1992 and 2004 as farms grew in size to take advantage of increasing returns to scale. Estimates of returns to scale provide insight into farmers' incentives to undertake further increases in scale.

The top of table 7 shows the change over time in the share of total finished-hog output produced by farms in each farm-size category. The increase in share was particularly notable for large operations. For example, so few farms were producing more than 25,000 hundredweight gain that they were not even sampled in the 1992 survey. By 1998, these operations produced 35.7 percent of total output, and the share rose to 43.4 percent by 2002.

The bottom of table 7 reports two estimates of average scale elasticity for all farms in each survey year—the mean and weighted mean. The mean scale elasticity for all farms ranges between 1.12 and 1.16, which indicates that a 10-percent increase in inputs produces an 11.2- to 11.6-percent increase in output for the "typical" farm. The mean weighted by farm output is the scale elasticity associated with the "typical" quantity of output. The weighted mean is smaller than the unweighted mean because larger farms produce more output and the scale elasticity declines with size of the opera-

Table 6

Decomposition of total factor productivity change (feeder to finish)

Item	Factor change (Annual growth rate) 1992-98	1998-2004	1992-2004
		Percent	
Technical efficiency	-1.7	0.8	-0.9
	(-0.3)	(0.1)	(-0.1)
Technology	13.5	25.6	42.5
	(2.1)	(3.9)	(3.0)
Scale efficiency	30.6	13.8	48.6
	(4.5)	(2.2)	(3.4)
Allocative efficiency	2.6	3.9	6.7
	(0.4)	(0.6)	(0.5)
Total factor productivity	45.1	44.1	109.1
	(6.4)	(6.3)	(6.3)

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

Table 7

Share of output and scale elasticity by farm size and year (feeder to finish)

Farm size category	1992	1998	2004
		Share of total output (percent)	
Cwt gain < 1,000	14.7	1.9	0.5
1,000 ≤ cwt gain < 2,500	35.0	6.7	3.0
2,500 ≤ cwt gain < 10,000	41.0	26.5	16.7
10,000 ≤ cwt gain < 25,000	9.3	29.2	36.3
25,000 ≤ cwt gain	id	35.7	43.4
		Scale elasticity	
Cwt gain < 1,000	1.20	1.24	1.27
1,000 ≤ cwt gain < 2,500	1.13	1.16	1.22
2,500 ≤ cwt gain < 10,000	1.08	1.12	1.17
10,000 ≤ cwt gain < 25,000	1.07	1.09	1.12
25,000 ≤ cwt gain	id	1.03	1.05
All farms (mean)	1.16	1.12	1.14
All farms (output-weighted mean)	1.10	1.05	1.07

id = insufficient data for legal disclosure.

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

tion. Both the mean and weighted mean values imply increasing returns to scale in all periods.

As expected, scale elasticity declines as farm size increases—large farms obtain smaller gains from increasing scale than do small farms. The technology used by farms in the largest category exhibits positive returns to scale. However, the potential for efficiency gains from further increases in scale appear limited for large farms—farms producing more than 25,000 hundredweight had an average scale elasticity of 1.05 in 2004. On the other hand, potential scale efficiency gains remain in the sector as a whole—farms producing less than 25,000 cwt accounted for more than half of all output in 2004.

Returns to scale increased in all size categories between 1992 and 1998 and between 1998 and 2004. This implies that holding output constant (output is approximately constant within each category), returns to scale increased steadily over time. Hence, the reduction in the contribution of scale efficiency to TFP (see table 6) results from a slowdown in the growth of average farm output (see table 1), not from a reduction in the optimal scale of production.[8] Because average farm size increased substantially over the study period, the average scale elasticity for all farms showed little change.

[8]The procedure for estimating the stochastic production function allows some parameters to vary over time, which permits scale elasticity and optimal scale to vary also. See the definition of scale elasticity in the appendix for more details.

Regional Differences in Productivity Growth

Productivity growth in the U.S. hog sector varied substantially by region between 1992 and 2004 (table 8). For feeder-to-finish farms, this study focuses on two major hog-producing regions: the Heartland (IA, IL, IN, KY, MO, and OH) and the Southeast (AL, AR, GA, NC, SC, and VA). Producers in the remaining surveyed States (CO, KS, MI, MN, NE, OK, PA, SD, TN, TX, UT, and WI) are placed in the "other regions" category.

Production shifted from the Heartland to the Southeast and other regions during 1992-98. The share of output produced by farms in the Southeast increased 12.2 percentage points, even though the share of feeder-to-finish operations located in this region declined 5.6 percentage points. A large increase in scale of production accounts for this increase in output share despite a decline in share of farms: average farm size in the Southeast increased almost tenfold. Farms in the Heartland, while representing roughly half of all feeder-to-finish hog farms in both 1992 and 1998, experienced smaller proportional increases in average farm output over this period, and, consequently, their share of total output declined by 22.5 percentage points.

Table 8
Summary statistics by region (feeder to finish)

Item	1992	1998	2004
		Percent	
Share of feeder-to-finish farms			
Heartland	54.7	55.9	48.9
Southeast	15.2	9.6	10.7
Other regions	30.1	34.5	40.4
Share of feeder-to-finish output			
Heartland	57.9	35.4	45.2
Southeast	20.1	32.3	24.7
Other regions	22.0	32.3	30.0
		Hundredweight gain	
Mean farm output			
Heartland	1,716	5,399	11,313
Southeast	2,333	20,771	25,074
Other regions	1,097	10,516	12,933

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

During 1998-2004, feeder-to-finish output share rebounded in the Heartland and declined in the Southeast. Heartland farms doubled in size while farms in the Southeast had much smaller proportional increases (though starting from a larger average size). As a result, the Heartland increased its share of output 9.8 percentage points over this period, while the Southeast decreased its share by 7.6 percentage points.

The decline in the output share and in the rate of growth in average farm size in the Southeast during 1998-2004 can probably be attributed largely to policy changes at the State level. Over the three survey periods, farms in North Carolina produced on average about 92 percent of total output in the Southeast region. In 1997, North Carolina passed the Clean Water Responsibility and Environmentally Sound Policy Act, which imposed a moratorium on the construction of new and expanded hog operations with 250 or more head. The moratorium contained several exceptions, including new construction using "innovative animal waste management systems that do not employ an anaerobic lagoon."[9] Though the moratorium was originally set to expire in 1999, North Carolina extended it several times in modified form through 2007.

[9]For full text of the bill, see: http://ssl.csg.org/dockets/99bsc-bills/2499b01nchb515cleanswine.html

Except for "other inputs" in the Southeast, all partial factor productivity measures in the three regions increased at similar annual rates between 1992 and 2004 (table 9). However, this pattern masks substantial differences in factor productivity between the Heartland and the Southeast during the two subperiods. While each of the three regions began in 1992 with approximately the same levels of factor productivity, from 1992 to 1998, farms in the Southeast experienced much larger increases in feed, labor, and capital productivity than did farms in the Heartland. Between 1998 and 2004, this pattern reversed, with farms in the Heartland increasing their feed, labor, and capital productivity more rapidly than farms in the Southeast.

Disaggregating the change in productivity for each region shows the extent to which changes in the scale of production, or differences in rates of technological change, allocative efficiency change, or technical efficiency change caused these shifts in productivity (table 10).[10] The regional changes in TFP are consistent with changes in partial factor productivity previously discussed (see table 9).

[10]For each region, the disaggregation used the estimated parameters for all farms and the input levels corresponding to the farms in that region. In other words, the production technology was assumed to be the same across regions, but the input mix varied according to the sample.

The average annual growth rates imply that between 1992 and 1998, TFP almost doubled in the Southeast but increased by only about a third in the Heartland over the same 6-year period. Between 1992 and 1998, technical progress contributed roughly equal amounts to the growth in TFP for farms in both the Heartland and the Southeast regions. However, the contribution of scale efficiency to TFP was much greater in the Southeast than in the Heartland (increasing annually at 9.0 percent versus 3.1 percent). The large increase in scale efficiency in the Southeast resulted from the region's rapid increase in the scale of production (see table 8), given the increasing returns to scale of the production technology.

Between 1998 and 2004, productivity in the Heartland rebounded—increasing by almost 60 percent, compared with only 36 percent in the Southeast. Increases in scale efficiency drove faster growth in productivity in the Heartland in the second period—scale efficiency increased at an

Table 9

Partial factor productivity by region and year (feeder to finish)

Input/Region	Partial factor productivity			Annual growth rate, 1992-2004
	1992	1998	2004	
Feed productivity (cwt gain per cwt feed)				
Heartland	0.286	0.314	0.764	8.5
Southeast	0.281	0.443	0.629	6.9
Other regions	0.243	0.313	0.625	8.2
Labor productivity (cwt gain per unit of hog enterprise labor[1])				
Heartland	2,070	3,019	6,187	9.6
Southeast	2,237	6,151	6,918	9.9
Other regions	2,584	2,919	5,373	6.3
Capital productivity (cwt gain per dollar[2])				
Heartland	0.091	0.097	0.238	8.3
Southeast	0.099	0.156	0.252	8.1
Other regions	0.075	0.111	0.234	9.9
Other inputs productivity (cwt gain per dollar[3])				
Heartland	0.327	0.491	0.541	4.3
Southeast	0.456	0.359	0.485	0.5
Other regions	0.248	0.491	0.490	5.8

[1]The labor input is a weighted index (Tornqvist index) of paid labor plus unpaid farm household labor that uses the labor expenditure shares for paid and unpaid labor as weights. The labor expenditures for paid labor are observed. Labor expenditures for unpaid labor are estimated using an imputed wage for unpaid labor.

[2]Capital is the "capital recovery cost"—the estimated cost of replacing the existing capital equipment (barns, feeding equipment, etc.).

[3]Other inputs are defined as real expenditures on veterinary services, bedding, marketing, custom work, energy, and repairs.

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

Table 10

Decomposition of total factor productivity change (feeder to finish)

	Annual growth rate		
	1992-98	1998-2004	1992-2004
Heartland			
Technical efficiency	-0.5	0.2	-0.2
Technology	2.2	3.9	3.0
Scale efficiency	3.1	4.4	3.7
Allocative efficiency	0.9	0.6	0.8
Total factor productivity	5.3	8.1	6.7
Southeast			
Technical efficiency	0.1	-0.6	-0.3
Technology	2.3	4.4	3.4
Scale efficiency	9.0	2.2	5.5
Allocative efficiency	1.4	-0.7	0.4
Total factor productivity	11.5	5.2	8.3
Other regions			
Technical efficiency	0.1	0.2	0.1
Technology	2.1	3.7	2.9
Scale efficiency	5.6	-1.5	2.0
Allocative efficiency	-0.7	1.1	0.2
Total factor productivity	6.7	3.6	5.2

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

annual average rate of 4.4 percent, compared with only 2.2 percent in the Southeast. The Heartland actually lagged slightly behind the Southeast in technological progress during this period.

In sum, average farm-size growth and the resulting improvements in scale efficiency explain most differences in productivity growth between the Heartland and Southeast since 1992. While the rate of technical change approximately doubled between the periods in each region, farms in all regions had similar rates of technical advance. This suggests that the adoption of new technologies, information, and genetic improvements diffused at similar rates across the Nation. Because farms in the Heartland operate at a smaller average scale than do farms in the Southeast, the Heartland retains greater scope for further scale efficiency gains.

Organizational Structure and Productivity

As documented earlier, the use of production contracts increased dramatically among feeder-to-finish hog operations since at least 1992 (see table 1). 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.

Recent ERS research showed 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.

Given the scope of structural changes in the industry since 1998, it is possible that the observed differences in productivity between contract and independent operations have diminished. Many less-efficient independent operations have exited the industry, and some independent operations have begun to contract. Key and McBride (2007) used data from the 2004 ARMS to examine whether production contracts remain associated with greater farm productivity. The authors 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.

The estimates of the magnitude of the productivity gains attributable to contracting suggest that these productivity advantages contributed to the recent growth in contracting in the hog industry. The apparent continuing link between contracts and productivity, along with lower grower income risk and improved coordination and timing of product delivery for contractors, suggest that the use of production contracts is likely to continue to expand.

The connection between contracts and productivity suggests that contracting may have played a role in the recent increase in the average scale of production. Because contract operations are larger operations on average, it will be larger operations that enjoy the productivity gains from contracting. Consequently, contracting may enhance the competitive position of larger producers vis-à-vis smaller producers.

Implications of Productivity Gains for Consumers

A main potential benefit to society of increases in hog farm productivity is lower food prices for consumers. How much have productivity gains in hog production been reflected in retail 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 plus a “normal” rate of return. Consequently, if the normal rate of return were constant and farm productivity did not change, then hog prices would be expected to track input prices.

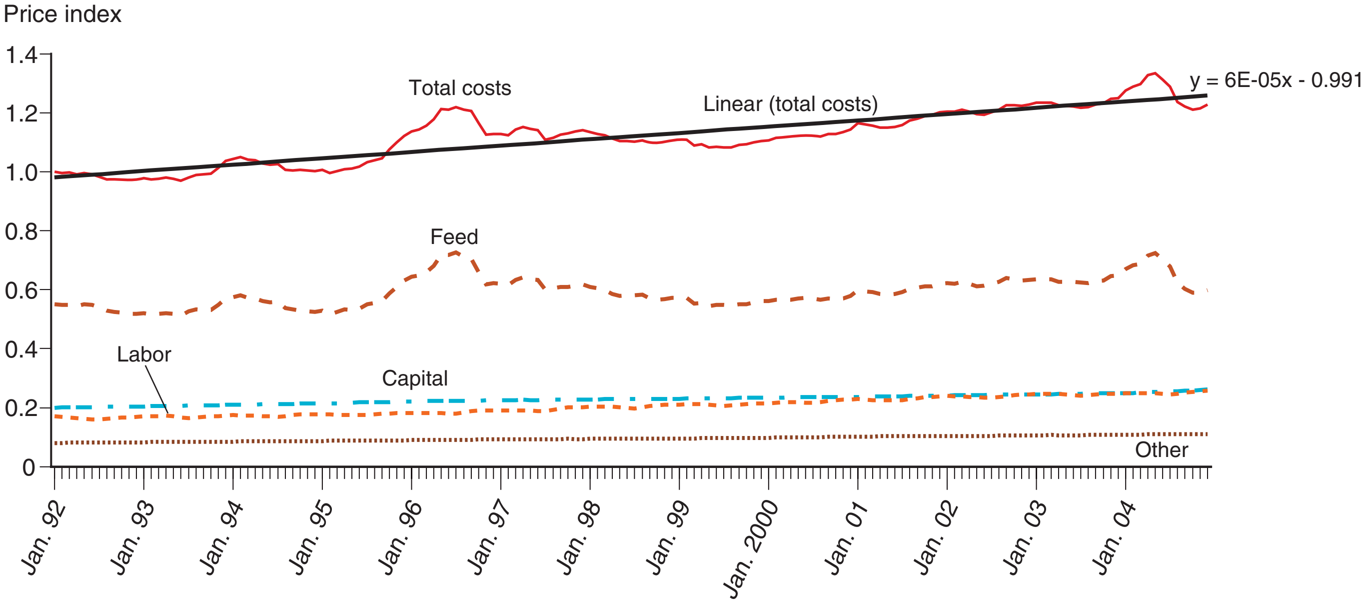
Figure 12 shows price trends for the major inputs to hog production. Each input price index is scaled so that the index at the beginning of the series (January 1992) equals the longrun average input cost share estimated using ARMS data. Specifically, at the beginning of the series, input costs comprised feed costs (55 percent), capital (20 percent), labor (17 percent), and other inputs (8 percent). The total input cost index is the sum of the input price indices, which equals 1.0 by definition in January 1992. The figure shows that feed costs, which fluctuated between 51 and 73 percent of total costs, drive the variation in the total cost index. A linear time trend fitted to the total cost index (heavy black line) indicates that input prices increased 28.5 percent over the study period. Since hog prices reflect the costs of production on the farm, this result implies that the gross farm value would have increased by about 28.5 percent between 1992 and 2004 if total factor productivity had not changed.

Figure 13 illustrates price trends at the farm, packer, and retail levels. The gross farm value is the value of the hog when it is sold, measured in cents per pound of retail weight. The wholesale value is the average value of the meat as it leaves the packing plant, measured in cents per pound of retail weight. The retail value is the average value of selected cuts of meat at the grocery store, measured in cents per pound of retail weight. The heavy black line shows an estimated linear time trend in the gross farm value of hogs. The estimated trend indicates that hog prices declined 3.3 percent between 1992 and 2004.

To summarize, input price increases imply that finish hog prices would have risen by 28.5 percent with no change in productivity. However, hog prices at the farm level actually declined by 3.3 percent. The difference between

Figure 12

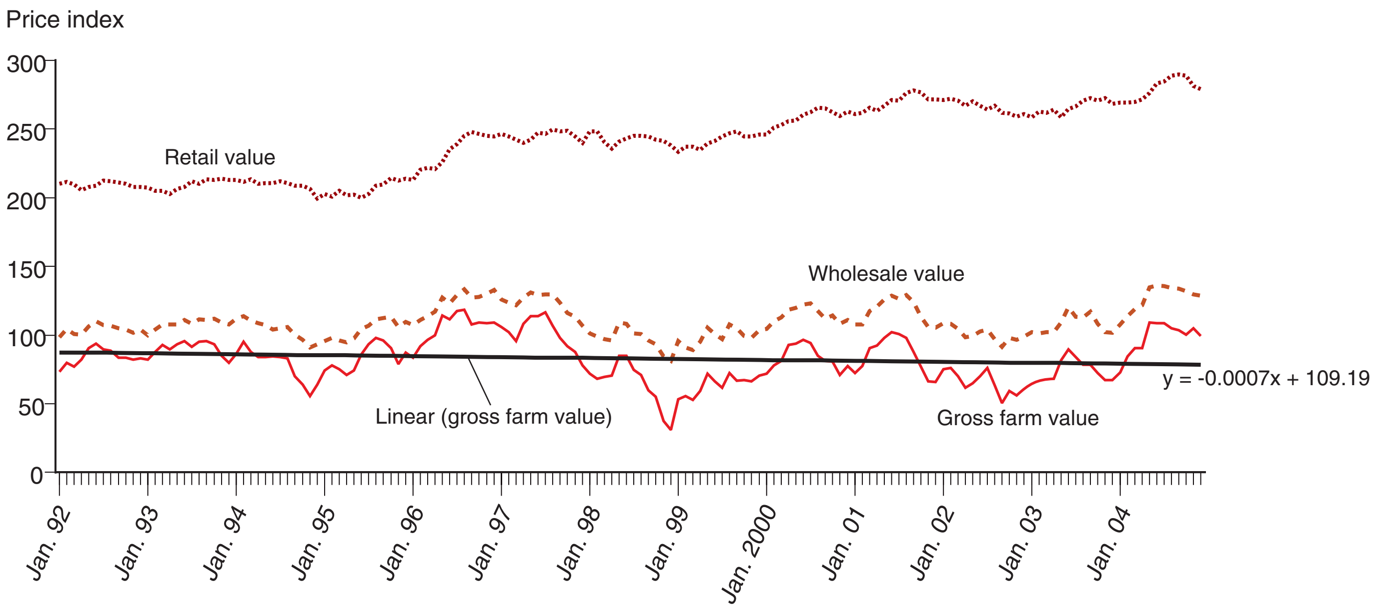
Historical pork prices—Gross farm value, wholesale value, and retail value, January 1992-December 2004



Sources: USDA, ERS using data from USDA, NASS, (farm wage rate); BLS (CPI; swine feeds, complete; farm machinery and equipment).

Figure 13

Feeder-to-finish hog production input price index, January 1992-December 2004



Sources: USDA, ERS using data from USDA, AMS, (wholesale and gross farm value); BLS (retail).

these price trends, 31.8 percent, represents the estimated decrease in the price of hogs at the farm gate attributable to productivity increases.

Productivity gains that lower finish-hog prices do not directly translate into lower retail prices. The cost of hogs represents less than a third of the total cost of retail pork (hogs must be slaughtered and processed, and pork must be transported and marketed).[11] Assuming finish hogs at the farm gate

[11]The share of the farm value of pork (net byproducts) in the retail value fluctuated between 26 and 33 percent between 2003 and 2006, and averaged 28.9 percent (see www.ers.usda.gov/data/meatprice-spreads/data/pork.xls).

accounted for 29 percent of the total cost of pork sold at retail, farm-level productivity gains would lower retail pork prices by 9.2 percent (29 percent of 31.8 percent), compared with estimated prices without the productivity gains. Wholesale pork prices (at the packing house) show a very similar trend to the farm gate prices (see fig. 13). In contrast, retail pork prices increased substantially over the same period. Factors that may have contributed to the rapid increase in retail 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).

The estimated 31.8-percent decline in hog prices attributable to productivity gains is consistent with the estimates of TFP gains for feeder-to-finish operations. The estimated 109-percent growth in TFP for feeder-to-finish operations between 1992 and 2004 (see table 6) implies a 52-percent decline in average costs for these operations over this period.[12] The cost decline in feeder-to-finish operations is expected to exceed the overall hog price decline for several reasons. First, finish hog prices are determined partly by the supply of hogs from farrow-to-finish operations, in addition to feeder-to-finish operations. As shown in table 4, farrow-to-finish farms achieved substantially smaller productivity gains than feeder-to-finish farms, implying a smaller decline in costs. Second, the total cost of producing finish hogs supplied by feeder-to-finish operations includes the cost of producing feeder pigs. However, feeder-pig costs are not included in this study's productivity analysis (output was measured in terms of hundredweight gain). If feeder-pig operations realized smaller efficiency gains than feeder-to-finish operations, the total cost of supplying finish hogs would decline by less than 52 percent.

[12]A TFP index is proportional to the inverse of an average cost index. From table 3, TFP was estimated to increase by 109.1 percent between 1992 and 2004, implying that a TFP index equal to 1.0 in 1992 would increase to 2.091 in 2004. The inverse of this index (the average cost), would fall from 1.0 to 0.478—a 52.2-percent decline.