Vertical Coordination in the Pork and Broiler Industries: Implications for Pork and Chicken Products. By Steve W. Martinez. Food and Rural Economics Division, Economic Research Service, U.S. Department of Agriculture. Agricultural Economic Report No. 777

Abstract

Recent changes in structure of the U.S. pork industry reflect, in many ways, past changes in the broiler industry. Production contracts and vertical integration in the broiler industry facilitated rapid adoption of new technology, improved quality control, assured market outlets for broilers, and provided a steady flow of broilers for processing. Affordable, high-quality chicken products have contributed to continual increases in U.S. chicken consumption, which has surpassed pork and beef on a per capita basis. Incentives for contracting and vertical integration in the pork industry may yield comparable results. If so, these arrangements might be expected to result in larger supplies of higher quality pork products at economical prices.

Keywords: Vertical coordination, vertical integration, contracts, transaction costs, technology, chicken, pork.

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Continual reductions in inflation-adjusted (real) chicken prices and response to changing consumer preferences played an important role in the growth of per capita chicken consumption since the 1940's. An increase in the value of households' time, reduction in household size, and information linking diet and health have led to consumer preferences for convenient and nutritious food products; and the broiler industry has responded. Broiler products have become more convenient; from New York dressed birds (head, feet, and entrails intact), to eviscerated whole birds, to cut-up birds and parts. After World War II, supermarkets replaced specialty meat markets. Broilers were appealing to both the supermarkets and consumers because of their relative ease of handling and preparation. In addition, because chicken meat was a good value, they were used as a price item to attract customers. Expansion of fast food chains also provided an opportunity to cater to consumer preferences through further processed products, such as nuggets and patties.

Contracts and vertical integration have helped increase broiler supplies, reduce chicken prices, and improve product quality and consistency. Production contracts between broiler growers and feed suppliers encouraged rapid adoption of new technology that created economies of size and lowered production costs. Control over quality and uniformity, provided through production contracts and integrated operations, facilitated the industry's response to changing consumer preferences for quality and convenience-type products.

Similar structural changes in both the pork and broiler industries suggest that incentives for the growth in contracting and vertical integration might be similar as well. The changing structure of the U.S. pork industry is also characterized by advances in technology, economies of size, and gains in production efficiency. Since 1990, larger supplies have lowered real retail pork prices. In addition, changing consumer preferences and ability to control quality attributes through advances in hog genetics, create incentives for controlling the quality of hogs produced.

Efforts to respond to consumer preferences for quality and convenience of pork products, in addition to economies of size, may lead to more rapid increases in contracting and integration in the pork industry. While some progress has been made in improving pork quality, per capita pork consumption has been stable over the 1990's. Contracting and vertical integration can provide greater control over the quality and uniformity of hogs that is necessary for responding to consumer preferences.

Like the broiler industry, the pork industry has seen periods of depressed prices. Although policymakers proposed stabilization policies in response to broiler price depressions in the late 1950's and early 1960's, the industry chose to remain free from government intervention. At the end of 1998, cash hog prices in the Midwest fell to levels not seen in 50 years. Unlike the broiler industry, the hog industry has a large base of independent producers that make price discrimination and decline in market outlets highly visible issues.

Glossary of Terms

Asset specificity: The degree to which assets serve a special purpose, with little value outside of their intended application.

Asymmetric information: Situation whereby traders have different information that is important in determining efficient behavior or in evaluating performance of the trading partner.

Bounded rationality: Limitations on the human ability to foresee all future possibilities when formulating decision plans.

Broilers: Young chicken produced for meat instead of eggs.

Grower: Typically a small producer that provides the labor and facilities in a resource-providing contract arrangement.

Industrialization: Term used to describe significant structural changes in agriculture. It is characterized by increased levels of capital and technology and changing methods of vertical coordination.

Integrator: Firm that controls, through contracts, vertical integration, or other means, several stages of production and marketing. In a contractual relationship, also referred to as contractor.

Market specification contracts: Commonly referred to as marketing contracts, these contracts specify a market outlet for the product and a method of pricing. The farm producer provides the resources and makes decisions regarding the production process.

Moral hazard: Modified behavior of a contracting partner after a contract has been entered. Occurs when contract performance is not readily observable.

Open market exchange: Traditional method of resource transfer in agricultural industries, whereby a firm remains uncommitted to a specific market outlet until the production process has been completed. Prices serve as the coordinating mechanism, generating signals for adjusting quantity and quality of product.

Opportunism: Behavior unconstrained by morality for the purpose of gaining a more favorable outcome in an exchange relationship.

Quasi rents: The difference between returns to an asset in its current use and its next best alternative use. As asset specificity increases, so does the level of appropriable quasi rents.

Quasi-vertical integration: A single firm owns a specific asset used by a supplier, but does not own the entire supplying firm.

Transaction costs: Costs associated with trading, besides the price. These include costs of searching for "best" price, and costs of monitoring and enforcing agreements.

Transaction cost economics: A branch of the new institutional economics that attempts to explain alternative methods of coordination based on the costs of transacting under each method.

Resource-providing contracts: Commonly referred to as production contracts, these contracts approach vertical integration in degree of control. The integrator provides important inputs into the production process, management services, and a market outlet.

Vertical coordination: Includes all the ways of synchronizing vertical stages of a marketing system (for example, open market prices, contracting, strategic alliances, and vertical integration).

Vertical integration: Method of vertical coordination representing the greatest degree of control that a firm can gain over another stage of production. Coordination of two or more stages occurs under common ownership via management directive.

Vertical Coordination in the Pork and Broiler Industries

Implications for Pork and Chicken Products

Steve W. Martinez

Introduction

The U.S. broiler (or young chicken) industry was the last of the poultry (for example, turkeys) and egg industries to develop, but now surpasses beef as the leader in meat production. After World War II, the broiler industry grew into one of the most integrated of U.S. agricultural industries. Today, integrators produce nearly all broilers under contract with growers. Per capita consumption of broilers in the United States increased more than 100-fold, from 0.7 pound in 1935 to 72 pounds in 1997, surpassing beef consumption for the first time in 1993.

The industrialization of the U.S. pork industry, currently under way, is also characterized by major changes in structure and organization, including changing methods of vertical coordination. Contracts and, to a lesser extent, vertical integration are replacing hog purchases on the open market. Approximately 40 percent of hog sales to packers were coordinated by contracts and integrated operations in 1998, compared with 11 percent in 1993 and only 3 percent in 1980.

Past studies of organizational changes in the pork industry have focused solely on the pork industry or have been largely descriptive in nature (for example, Rhodes; Hurt; Hyk). Few studies provided a comprehensive comparison of changing coordination in the pork and broiler industries. Yet, there are many similarities between current changes in the pork industry and past developments in the broiler industry. For example, contracting and vertical integration in both industries have been associated with new technology and new areas of production.

What can be gained by comparing vertical coordination in the pork and broiler industries? For one thing, such information can be used by policymakers to facilitate decisions regarding antitrust matters. Major changes in coordinating arrangements in the broiler industry occurred years ago. If similar incentives exist for contracting and integration in the pork industry, we might expect their effects to be similar as well. Efficiency-improving policies can be better formulated if firm behavior and factors influencing decision-making are better understood. In addition, useful input into current policy decisions in the pork industry may be gained by revisiting policymakers' response to changing coordinating arrangements in the broiler industry.

The major objective of this report is to compare, using transaction cost economics and other theories of firm organization, current changes in vertical coordination in the U.S. pork industry with past changes in the U.S. broiler industry. This comparison can be used to obtain a better perspective of the reasons for current changes in the pork industry and their potential effects. In the process, this report also examines the relationship between increased vertical coordination, retail prices, and market adjustments in response to consumer preferences for convenient, high-quality products.

The Role of Changing Vertical Coordination in the Broiler and Pork Industries

Although the term "industrialization" is used to describe current changes occurring in agriculture (Urban), it was also used to describe major structural changes in the broiler industry nearly half a century ago. As the broiler industry grew, contracts and vertical integration played an important role in the adoption of new technology and the coordination of production with consumer preferences. The industrialization of the broiler industry yielded gains in production and marketing efficiencies that lowered the costs of chicken products. At the same time, the industry achieved a level of control over production and processing that has enabled it to respond to consumer preferences for high-quality, uniform, value-added products.

The U.S. pork industry in the 1990's resembles, with some differences, the broiler industry in its industrialization process (Rhodes; Hurt; Barkema and Cook). These points are discussed below.[1]

Growth of the Broiler Industry[2]

Since the 1930's, relationships between vertical stages of the broiler industry (see box, "Vertical Stages of the Broiler Industry") have changed significantly. Coordination of vertical stages through production contracts and integrated operations facilitated the adoption of new technology and gains in production and marketing efficiency. Contractual arrangements between feed companies and broiler growers encouraged rapid adoption of new production technology. As the broiler industry grew, these contracts evolved in response to the changing needs of both the feed company and the grower. Vertical integration between production and processing activities resulted in further gains in coordination between chicken production and demand.

Background

Before the 1930's, nearly every farm had a small flock of chickens for egg production; chicken meat was a byproduct of these laying flocks. Most frying chickens were fowl, laying hens that had outlived their fertility. Young roosters (cockerels) that were superfluous to the egg-laying flocks were also sold as frying chickens as a spring delicacy.

At the time, opportunities existed to raise birds for their meat on a year-round basis. The genetics of the cockerels, however, were for desirable laying characteristics rather than for meat. Hen meat was tough, dry, and strongly flavored, while the quality of the cockerel meat was only fair. The popularity of spring chicken suggested that a market existed for establishing a year-round supply of chicken meat. In an effort to extend the seasonal consumption pattern, substantial quantities of chickens were stored and sold in the frozen New York dressed form.[3] Upon thawing, however, the meat was watery and of poor quality.

The profit potential inherent in broiler production became evident during World War II. Unlike the red meats, poultry was not rationed during the war, encouraging its consumption. Broiler price ceilings in place at the time were profitable to the farmer, but were commonly evaded so that actual broiler prices exceeded the ceiling price. Broiler production nearly tripled between 1940 and 1945, despite poor feed quality and heavy disease losses.

These developments likely played a role in the postwar allocation of capital to facilities and research. Adoption of technological advances in genetics, disease control,

[1]The discussion is patterned after the four-step structural change model developed by Reimund, Martin, and Moore, and recently applied to the Quebec pork industry (Gillespie, Karantininis, and Storey). These steps include (1) development of new technology, (2) production in new geographic areas, (3) growth and development, and (4) new methods of vertical coordination.

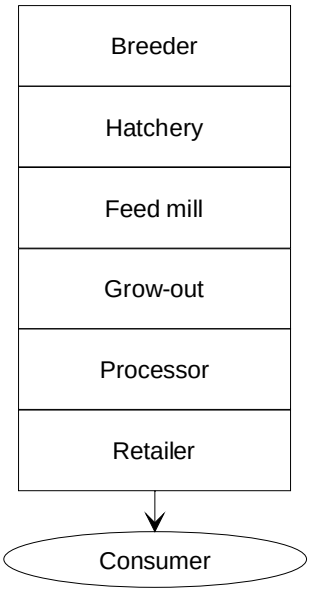
[2]This section is based on information contained in Sawyer; Knoeber and Thurman; Martin; Roy; Tobin and Arthur; G.B. Rogers; R.T. Rogers; National Commission on Food Marketing (NCFM); Bugos; Marion and Arthur; Hyk; and Mighell and Jones.

[3]"New York dressed" form refers to killing, blooding, and plucking the chicken without removing the head, feet, and inedible viscera.

Vertical Stages of the Broiler Industry

Vertical stages of the broiler industry include the breeder farm, hatchery, feed mill, grow-out farm, processing plant, and retail market. Feed is provided to both the breeder farm and grow-out farm. Eggs from the breeder farm are sent to the hatchery. At the hatchery, the eggs are hatched, and the chicks are sent to the grow-out farm, where the birds are grown to market weight, in about 6 to 8 weeks. The birds are then sent to the processing plant, where they are slaughtered and dressed. The dressed birds are ice-packed or chill-packed (air-chilled) as whole birds or cut into parts. Other birds are quick-frozen, either in whole form or as individual pieces, or are shipped to another company-owned plant for further processing into value-added products, such as frozen nuggets and dinners. Processors sell their output to further processors, distributors, or to retail outlets, composed of the food service segment (institutions and restaurants) and retail grocery stores.

Source: Rogers, 1992



nutrition, housing, and materials handling in the 10-year period following the war were substantial (see box, "New Technology in the Broiler Industry in the 1940's and 1950's"). These innovations increased the size of production units to achieve economies of size and resulted in substitution of capital for labor. In 1954, for example, no farms sold 100,000 or more broilers; by 1964, 12.5 percent of farms sold 100,000 or more broilers (Reimund, Martin, and Moore). With the development of chickens bred for meat quality, broiler production could develop independently from the other poultry enterprises.

Developments in Contracting

Although technological advances set the stage for growth and development of the broiler industry, most broiler growers operated independently at the time. The grower would buy feed from a dealer, chicks from a hatchery, and other supplies from another dealer. When the birds were ready for market, the grower would sell them to the processor who offered the highest price.

Financial resource requirements increased as production expanded and growers began operating broiler houses on a scale amenable to the new technology. Large capital requirements, coupled with declining, highly variable live broiler prices, made broiler production a risky business. Many broiler growers, especially those in the rural areas of the South, were either financially unable to operate or unwilling to assume the price risk.

Large feed companies recognized the broiler industry's potential for growth and the larger market that represented for their feed.[4] Consequently, they established production contracts with growers. These contracts later evolved to assure a market outlet for feed supplies, to reduce growers' financial and income risks, and to create incentives for growers to produce efficiently. Risk and management responsibilities were increasingly transferred to the feed companies, also referred to as integrators (see box, "How Contracts Evolved in the Broiler Industry").

Use of production contracts increased quickly. The first recorded broiler contract, signed in 1933, involved a joint sharing of risk and profit between a feed dealer and grower. In 1950, 95 percent of broiler producers remained independent (Roy). By 1955, however, after the large national feed companies moved into broiler-producing areas of the South, independent producers

[4]Feed is an important component of the grow-out stage, representing about 70 to 75 percent of grow-out costs.

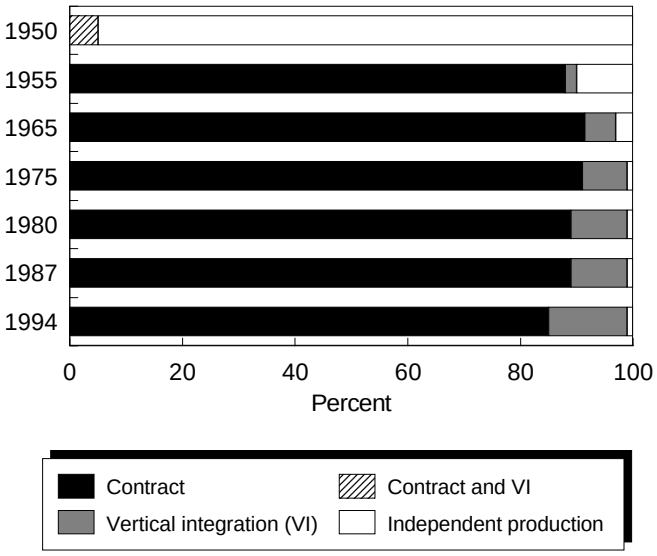
accounted for only 10 percent of total broiler production, whereas 88 percent were produced under a contract arrangement and 2 percent were produced in company-owned broiler facilities (fig. 1). Nearly all broilers are grown under contract or in integrator-owned facilities.[5]

With the decline of the cotton industry in the South, the broiler industry's shift to the use of contracts encouraged an expansion of broiler production there (Roy). In 1950, Georgia, North Carolina, Arkansas, Alabama, and Mississippi accounted for 27 percent of U.S. broiler production; by 1965, they had become the top five broiler-producing States in the Nation, accounting for 60 percent of U.S. production (National Commission on Food Marketing). Through vertical contracting arrangements, the use of excess labor at lower wage rates reduced production costs in the new production regions.[6] Hatchery efficiency gains also contributed to lower chick prices. In 1961, the cost of producing broilers in the Southeast was about 15 percent lower than on the Delmarva Peninsula (Delaware, Maryland, Virginia) (Roy).

Developments in Vertical Integration

As broiler production and consumption expanded at a rapid pace in the 1950's, supplies and prices became more unstable (Tobin and Arthur). Shortrun profitability considerations led to production decisions that did not account for longer range considerations affecting the industry.[7] Feed companies often did not communicate with buyers of dressed broilers, who provided market information. The feed companies were likely to be overly influenced by fluctuations in the markets for baby chicks and feed, and out of touch with day-to-day markets for dressed broilers. This situation created an imbalance between supplies and demand.

Figure 1
Proportion of broilers produced under contracts, vertical integration, and independent production
Production contracts increased rapidly after 1950



Note: Roy does not distinguish contracting and vertical intergration in 1950.
Source: Complied by ERS, USDA from Roy; Knutson, Penn, and Boehm; Marion; and Manchester.

The Poultry Products Inspection Act (PPIA) of 1957, which required USDA inspection of all broilers traded across State lines by January 1, 1959, placed additional pressure on the industry to increase production. Before 1959, USDA offered voluntary inspections of broilers for wholesomeness, the results of which were used as a competitive selling device. The PPIA was designed to instill consumer confidence and to protect against substandard health practices following a spate of deaths from bacterial disease traced to contaminated poultry meat. Many processors needed to make major capital investments to comply with the new sanitary requirements. Consequently, they built new plants to meet the inspection requirements. From 1958 to 1959, the percentage of broilers inspected increased from 25 percent to 75 percent. At the same time, capacity was increased and automated processing equipment was updated. Some increase in capacity, which would have occurred sooner or later, was squeezed into the 12 to 14 months before 1959 (Tobin and Arthur). Increased capacity allowed plants to cover the cost of capital investments only by operating at greater volumes of production.

[5]Contracts can vary according to the degree of control offered to the integrator. While most broilers were grown under contract by 1955, contracts continued to evolve.

[6]Contracting was familiar to southern farmers who had been sharecroppers (Bugos).

[7]Operating efficiently within a particular stage of a marketing system does not guarantee efficiency of the entire system. The goals of a single stage may not coincide with the goals of the other stages.

New Technology in the Broiler Industry in the 1940's and 1950's

Many important technological advances occurred in nutrition, medicine, buildings and equipment, and genetics in the 1940's and 1950's. Research on feed formulations led to substantial improvements in feed efficiency. In the process of studying vitamin B_{12}, researchers discovered that growth was being stimulated by properties that were unexplainable by vitamin B_{12} itself. This led to the discovery of the antibiotic Aureomycin (chlortetracycline), which led to a completely new era of nutrition research. Not only did antibiotics serve as growth stimulants, they had great value in disease control. This enabled flocks to be grown in confinement. In the early 1950's, antioxidants were introduced, which prevented rancidity in fat used in high-energy poultry rations.

To overcome the cost and tedium of feeding birds by hand, automatic feeding was introduced in the late 1940's, using a specially designed chain to carry feed along troughs throughout the house. Other equipment innovations included waterers, ventilation equipment, chick sorters, and feed cleaners.

Around 1950, advances in feed medications allowed poultry to receive medication through the feed. In addition, vaccination through drinking water was developed. These advances were also compatible with the larger commercial-sized flocks because the entire flock could be treated at once, which reduced labor costs.

Substantial investments were also made to develop strains of chicken that were bred strictly for their meat qualities. The "Chicken-of-Tomorrow Program," initiated in 1945, was an annual contest sponsored by the Great Atlantic and Pacific Tea Company that became instrumental in encouraging leading breeders to breed broilers for their meat qualities, particularly the yield of meat from breasts, thighs, and drumsticks.

Sources: Hyk; Tobin and Arthur; Sawyer.

In the spring of 1958, integrators placed additional orders to breeders for more pullets (young hens) to be placed in the hatchery supply flocks in response to higher broiler chick prices. This response to current chick prices was apparently made without regard to prospective demand for broilers several months in the future (Tobin and Arthur). At the same time, integrators were building their own hatcheries. The buildup in the hatchery supply flock in 1958 led to a 13-percent drop in live broiler prices from 1958 to 1959. Many hatcheries and feed companies experienced major losses because of overproduction and depressed broiler prices. By 1961, live broiler prices had dipped an additional 14 percent from the depressed 1959 levels.

Following these drops in broiler prices, further changes in organization occurred. To coordinate production capacity at each stage, feed companies became more directly involved in the broiler business. The feed and hatchery stages became integrated as many feed companies added hatcheries and expanded growing operations, possibly due to the volatility of hatching-egg prices faced by independent hatchery operators (Sawyer). Feed companies also developed closer ties with processors by acquiring or merging with processors and by building their own processing facilities (Sawyer). Processors' day-to-day exposure to the dressed broiler market gave them more market information than producers, so processors seemed in the best position to coordinate the hatching-egg operation. By integrating with the processing stage, feed companies came in closer contact with the market for dressed broilers and could therefore more closely coordinate broiler supplies with the consumer market for chicken.

As feed companies increased their processing operations, independent processors and independent producers found themselves with fewer markets for buying and selling broilers. Consequently, independent processors established their own contracts with feed companies to obtain birds or with growers to produce the birds (National Commission on Food Marketing). Many smaller independent producers were forced out of the broiler business, while others purchased their own processing facilities.

How Contracts Evolved in the Broiler Industry

Six basic types of contracts were used in the broiler industry, including (1) open account, (2) guaranteed price, (3) flat-fee, (4) sharing, (5) feed conversion, and (6) combination.

The first contracts between the integrator (usually a feed company) and growers were open *account contracts*. Under these arrangements, credit was extended that eased the grower's capital constraint. The growers provided housing, equipment, labor, fuel, and other inputs. When the broilers were sold, the grower repaid the debt. Profit to the feed company came from markups on inputs or a flat service charge. All profits and losses were sustained by the grower. As growers began to specialize in broiler production and rely on the business as a source of income, price and production risk became more critical.

Guaranteed price contracts lowered grower price and output risk and reduced financial constraints. Under these contracts, the feed company furnished supplies for a fee. Because the grower was guaranteed a certain price when the birds were sold, price risk was shifted to the integrator. When the contract price exceeded the cost of inputs, the grower received the difference. If the guaranteed price did not cover the cost of supplies advanced to the grower, the loss was canceled. Hence, some production risk was shifted to the integrator as well. Growers were still subject to input price risk and excessive capital requirements. Also, a guaranteed price encouraged shirking by the growers, resulting in poor-quality birds.

Flat-fee contracts became the most widely used arrangements in the 1950's and 1960's. The integrator provided feed, medicine, and chicks and retained title to the broilers. The integrator sent advisors to improve farm production practices. The grower was no longer indebted to the integrator for inputs. When the birds were sold, the grower received a "flat fee" per bird, pound, or week as compensation for labor and some inputs. Because growers were no longer indebted to the integrator for inputs, their capital requirements and output risk were reduced. In addition, input and output price risks were transferred to the integrator. Because grower payments were not based on feed efficiency, and growers' effort was not easily monitored, these contracts encouraged shirking.

To deter shirking, integrators developed variations of the flat-fee contract. Under *share contracts*, the integrator provided the chicks, feed, medicine, and fuel, while the farmer provided the house, equipment, and labor. Bird receipts in excess of integrator costs were shared by the integrator and farmer, thereby giving each a partial interest in the other's objectives. Losses were absorbed by the integrator. However, input price markups by the integrator were encouraged, so that profits to be shared were lower. In addition, growers were still subject to burdensome capital requirements and output price risk and had some incentive to shirk.

Feed-conversion contracts were designed to provide an incentive for improved production practices. A feed-conversion bonus was paid to the grower, along with the flat fee payment, based on pounds of feed per pound of bird. The farmer had less incentive to shirk because income was directly related to performance level. However, the grower was still subject to production risk and capital constraints.

Combination contracts combined the desirable attributes of the previously discussed contracts. These contracts usually involved a flat fee payment to the grower adjusted by some bonus payment to discourage shirking. A bonus was added to the flat fee, depending on profit-sharing, feed efficiency, mortality, or some other basis. In addition, the integrator commonly bases the bonus payment on the grower's performance relative to other similar growers, rather than on an absolute standard. For instance, a grower may receive payment based on an average cost of production, which is then adjusted up or down depending on the individual grower's cost compared with the average.

Source: Martin.

In the 1970's, many feed companies left the broiler industry because of depressed broiler prices and high input costs (Hyk). Processors took over ownership of almost all stages to gain efficiencies from improved coordination (Rogers, 1992). The processors' role as integrator was influenced by the significant economies of size in poultry processing and the large proportion of value added in processing (George Morris Centre).[8]

The major integrators recently expanded into the basic breeding of the broiler stock as well (Rogers, 1992). In 1985, a British subsidiary of the Cobb Company, a primary breeder owned by Upjohn, introduced the Cobb 500 female line into the United States. The Cobb 500 resulted in a large, easily deboned breast that provided 2 percent more breast meat. The new bird appealed to Tyson Foods, a large integrator that served most of the institutional market, where frozen, deboned breasts were sold. To prevent competitors from monopolizing the breed, Tyson initially purchased half ownership in the Cobb Company (Bugos). In 1994, Tyson increased its ownership interest to 100 percent by acquiring Upjohn's remaining 50-percent interest. The Cobb Company continued to improve the bird to produce larger and more uniform breast yields that Tyson demanded.

Productivity Gains

Rapid adoption of new technology had an unprecedented impact on production efficiency, costs, and output in the broiler industry. By 1990, a ton of feed could produce 43 percent more broiler meat than in 1955. More automated equipment, larger houses, and more productive birds increased the productivity of farm labor. In the late 1940's, approximately 5.1 hours were required to produce 100 pounds of broilers; that had declined to about 0.1 hour by the late 1970's (fig. 2). Production costs fell by approximately half in the two decades following World War II. Over the same period, deflated costs fell by 65 percent. In the early 1970's, deflated production costs continued to fall, despite rapidly increasing input prices (for example, feed and energy). Production efficiency gains generated a five-fold increase in broiler supplies from 1946 to 1957, and another five-fold increase from 1957 to 1997.

Developments in the retail sector also influenced the broiler industry. Following World War II, supermarkets, relying on price and advertising, replaced specialty meat markets to the benefit of the broiler industry. Supermarkets often used broilers as price leaders because they sold at lower prices than other meats. This practice reinforced consumers' perceptions of broilers as a good buy and played a role in the tremendous expansion in broiler consumption and broadening of the broiler market without direct promotional expense by the producer (Tobin and Arthur). In addition, selling eviscerated (cleaned and disemboweled) chicken appealed to the retailer because it saved butchers' time and to the consumer because it was convenient.

Current Status of the Broiler Industry

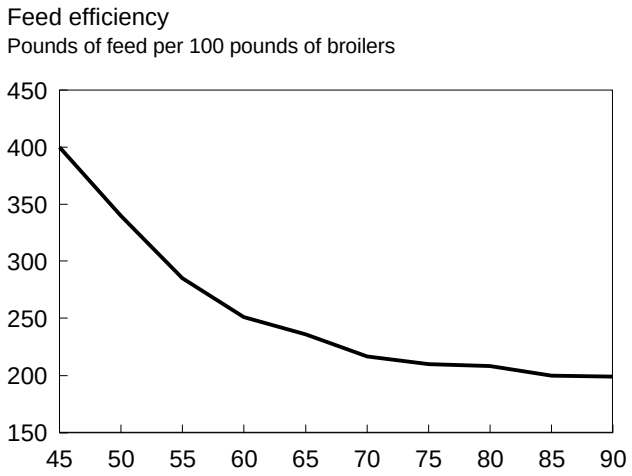
Most major processors control the vertical stages in the broiler industry, from breeders to market-ready products, through vertical integration and *resource-providing contracts*, typically referred to *as production contracts*. These processor-integrators, such as Tyson, breed the parent stock, produce hatching eggs, and hatch the eggs. Providing baby chicks, feed, veterinary services, and advice, they contract with growers to raise the chicks. Growers provide the chicken houses and labor. The production contracts specify a payment per pound of live broiler produced, depending on the grower's relative performance. The grown broilers are then slaughtered and dressed for market. Further processing may be accomplished in company-owned plants or by other processors who do not slaughter the birds. Plants are typically specially designed for the primary product form (for example, cut up, deboning, or product preparation for food service companies).

In such an integrated marketing system, the only point where basic supply and demand conditions generate a publicly visible price is at the interface between the processor and retailer (or distributor). As products become more processed, even this price information becomes less available. Many restaurants have entered long-term contracts with processors or distributors to avoid volatile broiler prices and offer stable menu prices for consumers (Rogers, 1992). While some con-

[8]Processors are now commonly referred to as "integrators" because of their involvement in the entire broiler subsector.

Figure 2
Broiler production efficiency indicators
Production efficiency has increased dramatically since the 1940's

Source: ERS, USDA.



Source: Compiled by ERS/USDA from Lasley;
Lasley, Jones, Easterling,and Christensen; and Rogers, 1992.

tracts are based on cost-plus formulas, the terms are not disclosed.

Recent Developments in Vertical Coordination of the Pork Industry

Many of the current structural changes in the pork industry resemble past changes in the broiler industry.[9] In both industries, new methods of vertical coordination are associated with new technology, geographical shifts in production, growth in firm size, and improved production efficiency. There are also differences between the industrialization process in the pork and broiler industries.

Technological and Organizational Innovations

New technological innovations and increased specialization in hog production are encouraging a larger number of animals at a given production site (Hurt). Advances have occurred in genetics, nutrition, housing and handling equipment, veterinary medicine, and management that improve the health of the hogs and reduce risks associated with hog production. This technology is applied to large production units to reduce fixed costs per hog. In the 1970's and 1980's, hogs were typically produced on farrow-to-finish farms, that is, farms with a breeding herd where the pigs are raised from birth to market. More recently, hog production has shifted to specialized farms at three different sites, separated by location. The first site is used for breeding, gestation, and farrowing. After weaning, the pigs are moved to a second site, a nursery facility, where they receive special diets and care. Once they reach 8-10 weeks of age and 40-60 pounds, they are transported to the finishing facility, the third site, where they are fed to market weight. This system reduces the risk of disease outbreaks and results in improved use of labor and facilities.

Paralleling the broiler industry, new methods of organizing hog production are contributing to industrialization. Large hog producers, typically referred to as integrators, or contractors, establish production contracts with smaller growers to feed the hogs to market weight. The producer-integrator provides management services, feeder pigs, medicine, and other inputs, while a grower provides the labor and facilities. In return, the grower receives a fixed payment, adjusted for production efficiency. These arrangements allow integrators to grow rapidly by leveraging their capital. For example, instead of investing in all buildings and equipment required for a farrow-to-finish operation, the integrator can invest in

[9]Stages of the pork system include the breeding stock sector, hog production sector, the packing/processing sector, and retail markets for pork products.

specialized facilities, such as farrowing units, while the grower may own the remaining facilities, such as the nurseries and finishing facilities. This arrangement allows the integrator to build more farrowing units, for example, because the integrator does not have to invest in nurseries and finishing facilities. By building more farrowing units with a given investment, more hogs can be produced. Integrators can also apply their management expertise in finance, genetics, nutrition, engineering, veterinary medicine, and animal husbandry to a greater number of pigs. Because the integrator provides many of the variable inputs and guarantees a payment to the grower, risk associated with input and output price variability is shifted from the grower to the integrator (Martin).

Growth in Nontraditional Regions

Like the broiler industry, the hog industry is growing most rapidly in areas that had not earlier produced many hogs, including the Southeast and, to a lesser extent, the West and Southwest. Growth in the Southeast is dominated by expansion in North Carolina, where hog inventories have more than tripled since 1989, compared with a 5-percent increase nationwide. North Carolina is now the second leading State, after Iowa, in hog inventories, and the leader in number of pigs born (pig crop). Slaughter capacity has followed hog production to nontraditional areas (Boehlje and others). Smithfield Foods, for example, recently opened the world's largest packing plant in North Carolina.

The dramatic increase in hog production in the Southeast is due in part to the increase in contracting in hog production and the decline in the tobacco industry. North Carolina farmers quickly accepted contracting because of the State's familiarity with production contracts in poultry. Lenders see contracting operations as a way to stabilize farm income in the face of potential losses in tobacco revenue (Hurt).

Hog producers in nontraditional areas of production can compete with the traditional areas because they can realize efficiency gains through improved managerial and production techniques. Large, environmentally controlled facilities, which spread costs over a larger number of animals and improve production efficiency, gave producers in emerging areas distinct cost advantages (McBride).

Structural Changes

Innovations in production have lowered costs for firms operating at higher levels of output. Most of the rapidly expanding large hog production operations are operating at costs that are $3 to $5 per hundredweight (cwt) below the costs of most more traditional operators (Rhodes). Large specialized farms have total costs of production that are 10.6 percent lower than smaller farrow-to-finish operations, excluding advantages in input prices (Good). Feed produced at large centralized mills and hauled to farms is replacing feed from small, onfarm feed mills. Larger feed mills may be able to manufacture feed with more precise ration formulation and more uniform nutrient content. They can usually buy ingredients in large volume at lower cost and quickly change ingredients in response to relative price changes. These factors may outweigh the cost of hauling corn to the mill and feed to the farm. The mill may be owned by a large-scale hog producer or by a producer cooperative, or it may contract to manufacture feed (Martinez, Smith, and Zering).

While declining real hog and pork prices have forced many small hog producers out of business, others have expanded production to reduce unit costs. Consequently, the number of hog farms has fallen, while average size has increased. Growth in the size of hog farms, led by the nontraditional areas of production, is indicated by the percentage of hogs on farms with 1,000 hogs or more. The percentage of hogs raised on operations with inventories greater than 1,000 head increased from 37 percent of the U.S. swine population in 1987 to 47 percent in 1992 and 71 percent in 1997. In North Carolina, nearly 98 percent of hogs resided on these large farms in 1997, compared with 63 percent in Iowa (the leading hog-producing State).

As new packing plants have increased in size in the 1990's, the number of federally inspected plants has fallen (USDA[f]).[10] The rapid shift to much larger plant sizes over the past decade reflects an effort to capture

[10]Packing firms tend to engage in further processing, but they may also sell their output to processors engaged only in further processing.

apparent economies of size. In 1986, 19 plants, accounting for 50 percent of total slaughter at federally inspected plants, had annual processing capacity that exceeded 1.5 million head. By 1997, 29 plants with 1.5 million head of capacity accounted for 84 percent of hogs processed. Six plants had annual capacity exceeding 3.5 million head per year in 1997 and accounted for 29 percent of all hogs processed in the United States.

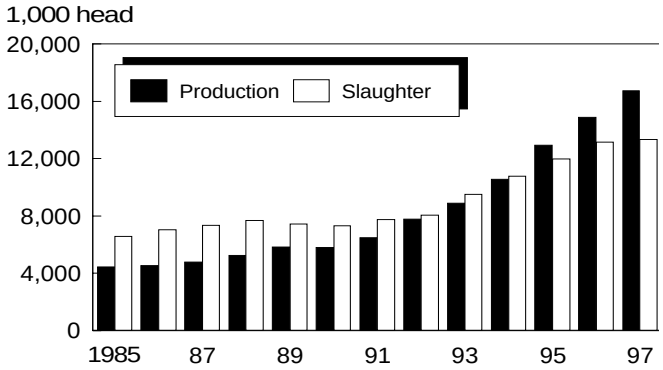
New Methods of Vertical Coordination

Hog production and packing have traditionally been coordinated through open market exchange, where sales are made after production is completed. In other words, the producer's position remains "open" until the product is ready for sale. Coordination is accomplished through price signals that provide incentives to adjust the quantity and quality of production. Higher prices for a particular product or quality bring additional resources into production. A grading system distinguishes demand for various quality attributes.

Market-specification contracts, commonly referred to as marketing contracts, between the large hog producer-integrators and large packers, are an important factor in the phenomenal growth of hog production in nontraditional areas. These contracts typically specify that the producer deliver a certain quantity of hogs, to a certain location, at a specified time. In return, the producer receives a market-based price that is adjusted for quality premiums. The contract assures large producers an outlet for their hogs and compensation for quality improvements. With a large, stable flow of high-quality, uniform hogs, the packer can reduce costs associated with variable supply flows, poor-quality hogs, and product losses due to condemnations and quality problems (such as excess fat or abscesses). In the North Carolina/Virginia region, hogs were imported until the mid-1990's, when production levels reached and surpassed slaughter quantities (fig. 3). Multiyear marketing contracts facilitated the coordinated growth in hog production and slaughter.

Multiyear marketing contracts between large packers and large hog producer-integrators are rapidly replacing open market transactions (fig. 4). In 1970 and 1980, less than 2 percent of hogs were obtained by packers through contracts or integrated operations. Hayenga

Figure 3
Hog production and slaughter in North Carolina/ Virginia region, 1985-97
Slaughter growth has been coordinated with production growth in the 1990's



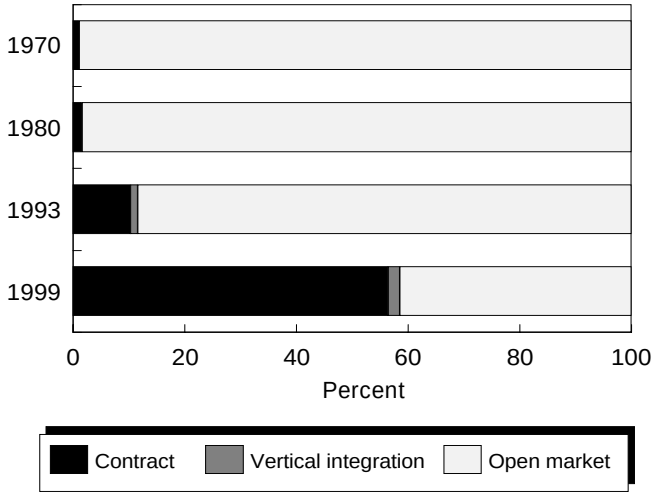
Source: Compiled by ERS, USDA from USDA [f,g].

and others (1996) surveyed 19 large packers in 1994, accounting for 86 percent of U.S. hog slaughter in 1993. Assuming that packers excluded from the survey do not contract or vertically integrate, the percentage of hogs obtained by packers from contracts and vertical integration in the United States was approximately 11 percent in 1993. The remainder was purchased on the open market using "spot" prices at the packing plant or company buying stations, or spot prices from dealers, order buyers, terminals, and auctions. In 1999, 59 percent of hogs in the United States were obtained through multiyear contracting or integration.

Changes in coordinating arrangements are also reflected at the breeder-producer interface. Small family farm purebred breeders are being replaced by large, highly sophisticated breeder companies who will often develop specific genetic lines for a large producer's own breeding herd (Schrader). A large breeding stock company can supply large producers with sufficient volume at one time. Smaller producers often buy replacement boars and gilts (young females) for the breeding herd by negotiation in an open market. Large producers, however, who tend to be on a schedule that requires specific timing and supplies of closely specified products, often use long-term arrangements to obtain gilts or boars (or semen) at formula prices.

Productivity gains in pork production have added significantly to U.S. pork supplies since the late 1970's. Technological advances have yielded more litters per

Figure 4
Share of hogs delivered for processing via long-term contracts and vertical integration
Substantial increases in marketing contracts have occurred in the 1990's



Sources: Compiled by ERS, USDA from Hayenga, Lawrence, Rhodes, and Grimes; Marion; and University of Missouri and National Pork Producers Council.

sow, more pigs weaned per litter, and improved feed efficiency. The average number of pigs weaned per litter reached 8.64 in 1997, compared with 7.04 in 1978 (fig. 5). Heavier hogs and greater dressing yields at the packing plant have led to increased meat production per hog. A given quantity of pork meat can now be produced with fewer hogs, less labor, and less feed. Because of these productivity gains, pork production per head of breeding stock rose from 1,400 pounds in 1978 to 2,500 pounds in 1997 (fig. 5). Industrialization of the pork industry has been especially apparent since the 1990's, which heralded the arrival of the "mega producers" (operations with inventories of at least 2,000 head). The percentage of the U.S. swine population raised by the mega producers nearly doubled from 28.8 percent in 1992 to 55 percent in 1997 (USDA[e]). Since 1990, total pork production has increased by an annual average of 1.8 percent per year. In the 1980's, the annual average increase in pork production was 0.5 percent.

Differences Between the Broiler and Pork Industries

Although significant changes in organization are occurring in the pork industry, there are some differences between the pork and broiler industries. The broiler marketing system remains more highly integrated. Breeding, feeding, hatching, and processing are vertically integrated functions, while production contracts are used to coordinate production with processing (fig. 6). Marketing contracts are relatively unimportant for the broiler industry. On the other hand, marketing contracts between the hog producer-integrators and packers (processors) are becoming increasingly important. Marketing contracts give the packer less control over production than do the production contracts used by the broiler processor-integrators. Production contracts between large hog producer-integrators and growers also are becoming more important. These contracts are similar to those between broiler growers and processors. Distinguishing between production and marketing contracts in the pork industry is especially important because they serve different functions.

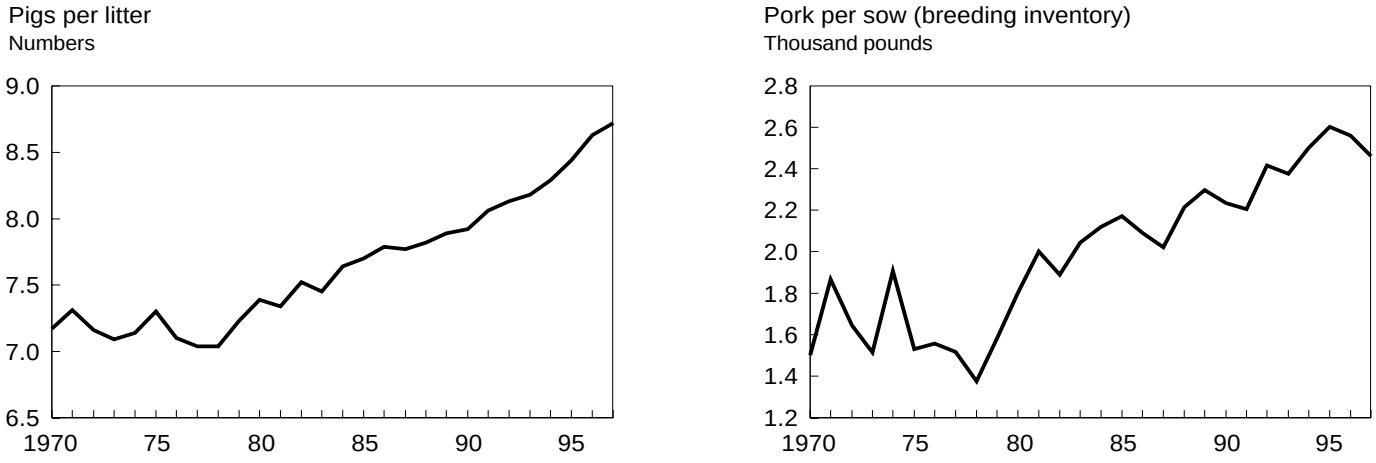
The pork industry is faced with several obstacles to a continuation of recent trends in organization. Unlike the broiler industry, the pork industry has a large core of independent hog producers selling on the open market. These producers will likely resist further moves toward contracting and integration in the hog industry, despite the competitive pressures placed on them to find a market for their hogs.

As consumers have become more concerned about the effects of their food choices on the environment (Kinsey), potential air and water pollution associated with manure from large hog operations may also create obstacles to further expansion. The pork industry mastered a method of organizing production that could be quickly replicated, which enabled rapid growth of hog operations. This seriously taxed existing environmental regulations and has led some States, North Carolina for instance, to impose moratoriums on new large hog production units. In addition, some localities have attempted to enact strict local ordinances that supersede existing State laws. Local residents often fear that unchecked expansion of hog operations will lower the quality of life and land values by contaminating water and air. On the other hand, large producers are concerned that stricter environmental regulations will limit their ability to reap the benefits of size economies associated with new technology. In addition, some legislative leaders claim that the large hog operations are important to their State's economy.

Figure 5

Efficiency gains in hog production

The pork industry has experienced substantial gains in productivity in the 1980's and 1990's

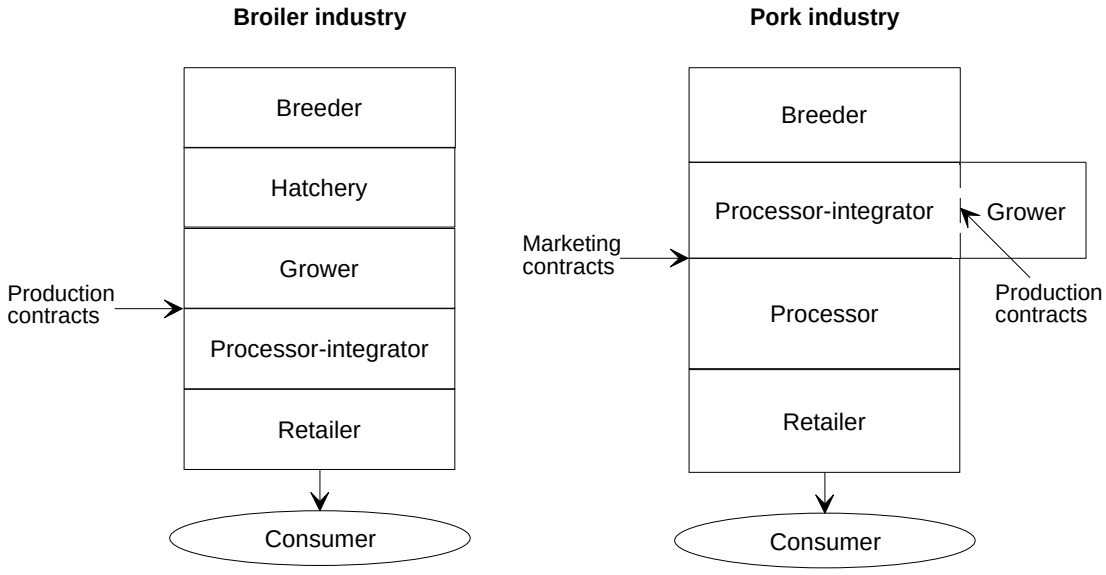


Source: ERS, USDA.

Figure 6

Production contracts and marketing contracts in the pork and broiler industries

Marketing contracts in the pork industry offer the processor less control over production than production contracts in the broiler industry



Application of Vertical Coordination Theories to the Broiler and Pork Industries

As defined in the pioneering effort by Mighell and Jones, vertical coordination includes all the ways that vertical stages of a marketing system are synchronized. Methods of coordination can be classified according to the degree of control over other vertical stages. At one end of the spectrum is *open market coordination*, representing the least control. Open market coordination refers to sales that are made after production has been completed. At the other end of the spectrum is *vertical integration*, representing the most control. Vertical integration refers to ownership and management of two or more successive stages of the marketing system by a single firm. Intermediate forms of coordination, which lie between open market coordination and vertical integration on the spectrum of control, include *quasi-vertical integration and contracting*. Quasi-vertical integration occurs when a firm owns a specific asset that is used by one of its suppliers. Contracting includes market-specification contracts and resource-providing contracts. Market-specification contracts typically specify a market outlet, delivery schedule, and method for determining the price. Resource-providing contracts, in addition to providing for a market outlet, provide for direct participation by both parties in the management of farm production and the provision of important inputs.

There is extensive theoretical literature regarding the motives for contracting and vertical integration. This section applies this theory to the broiler and pork industries. Incentives for contracting and vertical integration include reducing transaction costs, reducing price and quantity risk, and financing production inputs.[11] By understanding the motives for such arrangements, one can better understand their potential effects on the quantity, quality, and prices of pork and chicken products.

[11]Motives related to market power also exist. Discussion of these motives is in the section "Policy Responses to New Methods of Vertical Coordination."

Transaction Costs

Transaction costs are expenses associated with carrying out a transaction. These include costs related to: insufficient information regarding terms of the transaction; searching for the "best" price; negotiating, monitoring, and enforcing contracts; and costs of relaying information in vertically integrated operations. *Transaction cost economics* seeks to explain the variety of organizational arrangements that are used to coordinate resource transfers across stages of production. The central theme underlying transaction cost economics is that the efficiency of alternative organizational arrangements is measured by the costs of trading under each (Masten). Contracting and vertical integration in the broiler and pork industries offer incentives for reducing transaction costs associated with asset specificity, measuring and sorting costs of the traded goods, and assuring supplies and market outlets.

Asset Specificity

An important feature of industrialization in both the broiler and pork industries is the development of new production technology. Advances in feed formulations, production facilities and equipment, nutrition, and disease control result in scale economies for larger operations. Genetically improved breeding stock enable producers to select highly productive animals with traits that producers, processors, and consumers value.

Highly technical production processes may require specific assets—assets whose value is much greater in a particular use than in the next best alternative. Specific assets include physical, site, and temporal forms. An asset's unique physical characteristics can make it a specific asset. Hatcheries, broiler houses, feed facilities, and processing plants, for example, can be considered specific assets because they have few alternative uses (Reimund, Martin, and Moore; Sawyer; Marion and Arthur). An asset's location can also make it a specific asset. When one party to a transaction, for example, locates its facilities close to the other party in an attempt to lower transportation costs, the asset may

acquire a site-specific value. Temporal specificity arises when the timing of performance is critical, such as with perishable agricultural commodities (Masten). Many vegetables, for example, require processing soon after harvest to maintain quality (Manchester). After farmers invest in production inputs, processors may delay delivery to extract price discounts.

Specific assets may generate quasi-rents, which measure the value of the asset in excess of its next best alternative use. To illustrate, consider the example provided by Gallick. A horse carriage can be rented to transport tourists for $180 per day or rented as a museum piece for $100 per day. In this case, the quasi-rent is $80 per day.

Opportunistic behavior (self-interested behavior unconstrained by morality) may reallocate quasi-rents from the owner of the specific assets to the trading partner. Once the owner has invested in the specific assets, the other party may offer a lower price than specified before the investment. However, whether the quasi-rent is appropriable depends on a small-numbers condition (small number of bidders in the market) (Williamson, 1975).[12] Continuing the example, if there is only one bidder for the horse carriage to transport tourists, then the entire quasi-rent could potentially be appropriated by that bidder. That is, the bidder could decide to pay less than $180. As long as the offer exceeds the value of the carriage as a museum piece ($100), the owner of the carriage is better off renting it to transport tourists. However, if there are several bidders for the carriage to transport tourists at $180 per day, then the $80 in quasi-rents would not be appropriable. As asset specificity increases, parties become more susceptible to opportunism in the presence of few bidders (Williamson, 1975).

The threat of opportunistic behavior may result in welfare losses because mutually-advantageous trades do not occur (Milgrom and Roberts). For example, investment in a large-scale production operation that benefits producers, processors, and consumers may not be made for fear of opportunism.

[12]This point was contributed by Jim MacDonald, ERS.

The use of specific assets to produce intermediate goods may serve as an incentive to vertically contract or integrate to protect the asset owner from opportunistic behavior (Klein, Crawford, and Alchian). Contracts can help to place limits on acceptable behavior. Vertical integration can alleviate adversarial relationships.

Asset specificity in the broiler industry is significant, which may influence the types of coordinating arrangements used. Broiler housing facilities, processing plants, and breeding stock have a low value outside of their intended purpose (physical asset specificity).[13] Broiler growers tend to be located close to feed mills and processing facilities because broilers are perishable commodities (temporal specificity) and transportation costs of feed, chicks, and grown broilers are high (site specificity) (Lajili; Marion and Arthur).[14] Because processing must occur soon after production has been finished, broilers are considered to be perishable. Delays at this stage may elicit price concessions from the producer who would be hard pressed to find alternative markets on short notice. Following the broiler depression in the early 1960's, feed suppliers integrated with processors to assure themselves of a market for their broilers. (Hog producers, however, may have more time to find suitable market outlets. Temporal specificity may partially explain why the broiler industry has integrated its production and processing stages, while the pork industry is coordinated through marketing contracts.) Another form of asset specificity in the broiler industry is site specificity. Spatial concentration of processor-integrators may reduce the number of alternative trading partners for the broiler growers because the processor-integrators prefer to obtain broilers within a 20-mile radius (Rogers, 1992). Contracts between growers and an integrator reduce the likelihood of opportunistic behavior on the part of the integrator.

Investments necessary to take advantage of economies of size in hog production and processing may also be considered as site-specific assets (Martinez, Smith, and

[13]In addition, when feed mills entered the South, they were specialized facilities designed for serving the broiler industry (Sawyer).

[14]Processing plants tended to locate closer to broiler production areas as advances in transportation allowed dressed broilers to be transported greater distances (Rogers, 1992).

Zering). These substantial investments are highly specific to both parties and neither can survive in the long term by transporting hogs long distances. Producers located near one or a few processors may be subjected to opportunistic behavior by the processor. Once the producer's facilities are built, the processor may attempt to gain some of the quasi-rents accruing to the producer by offering lower prices for hogs. Similarly, a processor that locates in an area with few producers would be subject to opportunistic behavior by the producer. In this case, quasi-rents are the difference between the local price and the price of more distantly located hogs.

Multiyear marketing contracts between hog producers and processors may reduce the likelihood of opportunistic behavior related to site-specific assets. Asset specificity, together with the small-numbers condition, may account for the disparity in procurement methods used by the two largest pork packers, Smithfield Foods and IBP. Smithfield owns approximately 10 percent of the hogs that it slaughters and obtains 52 percent from multiyear marketing contracts with several large hog producers (Smithfield Foods, Form 10K, filed with Securities and Exchange Commission July 25, 1997). It also possesses 72 percent of packing capacity in the South Atlantic region (North Carolina, Virginia, South Carolina, Georgia, and Tennessee). On the other hand, IBP's main supply of hogs is purchased daily on the open market by buying agents (IBP, Form 10K, filed with Securities and Exchange Commission March 26, 1998). IBP is located in the North Central region (Illinois, Iowa, Minnesota, Missouri, Kansas, Indiana, Nebraska, South Dakota, and Kentucky), where no one packer possesses more than 25 percent of available packing capacity. Hog producers also tend to be smaller and more numerous in the North Central region than in the South Atlantic region.

Marketing contracts can also reduce the incidence of opportunistic behavior associated with investments to improve hog quality (physical asset specificity). Once a producer makes the investment, the premium for the higher quality hogs becomes a quasi-rent that can be appropriated to the packer (Martinez, Smith, and Zering). The producer can either accept the lower premium or sell the hogs on the open market and receive no premium. For example, carcass value pricing, which refers to carcass weighing and inspection after slaughter to determine price premiums and discounts, has become the chief method for pricing hogs.[15] Packers currently pay premiums to producers of large and lean hogs. Selection of breeding stock to produce leaner hogs, however, has led to increased incidence of the stress gene, which is associated with pale, soft, exudative (PSE) pork (tough, dry, and lean pork).[16] Investments in breeding stock to reduce the incidence of PSE pork may be considered a specific asset. Once the investment is made, the premium for PSE pork over the open market price offered by the packer becomes a quasi-rent that can be appropriated to the packer. Because open markets do not include premiums for hogs bred from genetic lines that are free of the stress gene, the packer can lower the premium initially offered. The producer can either accept the lower premium or sell the specially bred hogs on the open market for no premium. Marketing contracts that specify payment of quality premiums reduce the likelihood of this type of opportunistic behavior.

Furthermore, premiums can vary substantially among packers because they have different processing equipment and may serve different markets. They may also use different methods to determine carcass premiums and discounts. For example, because consumers prefer consistency in the products they purchase, packers discount their prices for carcasses that do not provide the size of cuts desired. An analysis of carcass value pricing schemes used by 10 large packers found that 2 packers paid no premiums for lean, when carcasses were below 160 pounds, while other packers paid a range of premiums (Kenyon, McKissick, and Lawrence). Seven packers used backfat and loin depth to compute percent lean, while three packers used backfat measurement only. Differences among pricing schemes, which make it difficult for producers to compare prices, increase the potential for opportunistic behavior by the packer after the producer has invested

[15]Historically, hog prices were negotiated on the basis of live weight.

[16]Pale, soft, exudative pork occurs when the muscle from the pork carcass is pale in color, has a soft texture, and is watery (exudative). Because PSE pork is more susceptible to moisture loss, processors and retailers can experience significant costs due to reduced processing and storage yields. Panel scores suggest that pale-colored pork is less acceptable to consumers (McKeith, Ellis, and Carr). PSE pork is also less tender because of increased cooking losses.

in specific breeding stock. Long-term marketing contracts can reduce the likelihood of opportunism in the production of pork with unique quality characteristics.

Measuring and Sorting Costs

Quality attributes of the raw product may have an important influence on processing costs and value of the final product. For example, processors may reduce their costs by processing leaner hogs because of lower handling costs and more salable meat. In addition, consumers may be willing to pay a premium for leaner pork. In the pork industry, important quality factors for processors and consumers include hog size, leanness, uniformity, and PSE. Important quality attributes for processors and consumers in the broiler industry include size of the birds, uniformity, and yield of high-value breast meat.

Measuring and sorting costs associated with quality attributes of the raw product can be reduced by contracts between the producer and processor or by vertical integration. Producers and processors may have different information for determining whether the terms of a transaction are acceptable or whether they are being met. This situation is referred to as *asymmetric information*. For example, producers may have more accurate information regarding the quality of their product. If this information is freely available, then equally valued products will sell at an equal price. When quality information is costly to obtain, however, producers may attempt to sell high- and low-quality products at the same price. Hence, buyers may demand costly measurement of raw product attributes to determine its value, and inaccuracies could result in wealth transfers (Barzel). In addition, if quality attributes of the raw product vary, then costly sorting may be required to determine its value. If the quality of the intermediate or final product can be controlled by the producer, however, then the processor can reduce the cost of presale measuring and sorting by changing the method of coordination. Long-term contracts that specify quality attributes, and direct control through vertical integration, may reduce the need for costly measuring.[17] Contracting or vertical integration becomes more likely as the value of the good becomes more uncertain because the opportunity for exploiting errors in measurement increases.

To illustrate, consider the following example paraphrased from Barzel. While the weight of an orange can be measured at virtually no cost, weight provides little information as to the true value of the orange. The skin of the orange hides information regarding its taste and juiciness, and direct measurement of these attributes by peeling and squeezing at the time of purchase is costly. Hence, the quality attributes of the orange are subject to measurement error. The producer may attempt to exploit errors in measurement by charging equivalent prices for both low- and high-quality oranges. To prevent such opportunistic behavior, the purchaser may incur expenditures to measure the value of the oranges. New methods of coordination, however, may limit expenditures for this purpose: 1. If a seller agrees to deliver a certain quality of oranges under a contractual agreement, the purchaser's need for presale testing of quality declines: 2. By combining both the production and processing of the oranges in a single firm (vertical integration), the need for costly measuring is lessened.

On the open market, several buying agents may be required to purchase hogs that conform to the specifications of the packer. Attributes that are difficult to measure at the time of grading, such as PSE, may require costly testing that is prone to errors. Because the value of hogs is largely determined by genetics and weight, the use of long-term contracts between producers and packers that specify quality characteristics may reduce measuring and sorting costs. Large packers favored long-term contracts chiefly as a means of assuring the quality and consistency of hogs (Hayenga and others). Half of the large packers surveyed required minimum quantity and quality specifications or specific genetic requirements. Direct control through vertical integration can also reduce measuring and sorting costs.

The broiler industry uses production contracts and vertical integration to control size, aesthetics, and uniformity for meeting the quality requirements of slaughter plants and the specifications of retail customers. Because many contract growers supply one processing facility, replication of growing conditions, such as the

[17]Hennessy develops a theoretical model that demonstrates incentives to vertically integrate because testing for quality is costly and subject to error.

use of high-quality inputs, and proper management, are very important for producing high-quality, uniform birds. The specific requirements of production contracts reduce variations in birds across grower flocks and over time. The contracts generally provide management services and may require each facility to have the same equipment. Growers are trained in proper management practices. Water and feed placement, for example, can have an important effect on broiler quality as chickens may suffer scratches on their skin from crowding around an inadequate number of feeders (Stillwell). Feed ingredients and genetics also have an important influence on broiler quality. By vertically integrating into breeding, most of the major processors directly control the genetics of the breeder chicks (Rogers, 1992). Feed from processor-owned feed mills also helps to ensure that each grower obtains similar, customized feed ingredients.

With uniformity of birds resulting from control over production inputs and management services, mechanized processing and handling became possible (Bugos; Rogers, 1992). This is illustrated by the procedure used to slaughter birds. Live broilers are hung by their feet on shackles that roll by on a chain. As they move through the plant, they are electrically stunned, bled, plucked, and eviscerated, emerging as dressed broilers. Throughout the entire process they are seldom touched by human hands. Such automation would not be possible with varied body shapes. In 1961, Holly Farms became an integrated company by adding hatcheries, feed mills, a breeder flock, and a processing plant, and contracting for broiler growing. By 1964, Holly Farms was the first to commercially market broilers that were prepackaged at the processing plant, which required close quality control at all stages (Marion and Arthur).

Production contracts with growers can also reduce measuring and sorting costs related to pathogen content by allowing the processor to implement quality controls quickly and thoroughly. Stricter food safety performance standards place a greater burden on the slaughter plant, which in turn, places greater pressure on live production to help meet the stricter regulations (Stillwell). As additional research into pathogen control proliferates and new management practices are identified, these practices can be quickly implemented through production contracts. Furthermore, production contracts provide a means of tracing the animals back to the farm of origin.

Supply and Demand Assurance

By contracting or vertically integrating, firms may increase the likelihood of obtaining a given flow of live animals to avoid costly overuse or underuse of processing facilities. Modern, efficient processing plants can lower unit processing costs, as well as retail meat prices, compared with older and smaller plants (fig. 7). Large fixed costs associated with processing, however, suggest that deviating from the optimal utilization level can lead to substantial increases in costs. In modern processing plants designed to operate efficiently at a stable output level, costs rise quickly when output is highly variable (Barkema and Drabenstot). This is illustrated in figure 7 by the more sharply sloped shortrun average cost curve for modern plants (SRAC'). When the flow of raw inputs is highly variable, variations in output lead to larger increases in per unit costs than with the older plants. Hence, it becomes more important to control the quantity and scheduling of live animal inputs.

Contractual arrangements have been used in both the broiler and pork industries to assure supplies of live animals. Large packers indicate that "increased volume" of hogs delivered to the slaughter plant is an important reason for multiyear marketing contracts (Hayenga and others). Marketing contracts may specify the number of hogs per day or week to be delivered.

Contracting and integration can also reduce uncertainties related to market outlets. Feed suppliers found that by establishing production contracts with broiler growers, they were assured of a potentially large market for their feed supplies. Large hog producers ranked "assured market outlet" for their hogs as the most important reason for contracting (Hayenga and others).

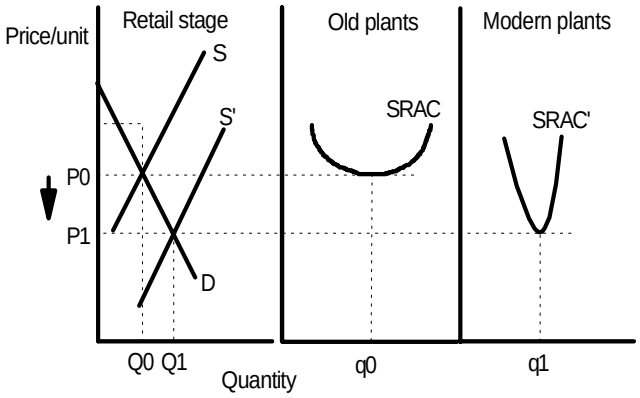
Price and Production Risk

Price and production risks in agricultural industries can lead to highly variable incomes. The relationship between inputs and output is subject to many uncertainties, such as weather, disease, and accidents. A portion of this production risk is specific to the particular

Figure 7

Effect on the retail stage of operating processing plants at optimum capacity

Modern processing plants are more efficient, but that efficiency comes at a price; the steeper curve in the modern plant means that its costs rise quickly if the volume of production varies much from the optimal level



Note: S and S' are the aggregate retail supply curves associated with production in old and modern plants, respectively. D is aggregate demand at retail. P0 and Q0 are the equilibrium retail price and quantity, respectively, associated with production in old plants. P1 and Q1 are the equilibrium retail price and quantity, respectively, associated with production in modern plants. SRAC and SRAC' are the shortrun average cost curves associated with old and modern plants, respectively. q0 and q1 are production levels associated with the minimum of the shortrun average cost curve for the old and modern plants, respectively.

Source: Compiled by ERS, USDA from Barkema and Drabenstott, 1990.

producer, such as equipment problems, while other risks are common to many producers, such as weather conditions. Producers also face risk related to market prices of inputs and output.

By paying producers according to a relative measure of performance, contracts can serve to shift price and production risk from producers to integrators.[18] Price risk for live broilers is not borne by the growers because their payment is independent of feed prices and broiler market prices. In addition, growers receive a payment that depends on their performance *relative* to others. When each grower's performance is affected, the payment remains unchanged. This reduces production risk that is common to each grower, such as unfavorable weather. Growers still bear that portion of production risk that affects only the performance of their flock.

Broiler industry production contracts evolved to transfer more price and output risk from the grower to the integrator.[19] Disease and heavy mortality were originally the main sources of uncertainty. As disease losses decreased, prices became a relatively more important source of uncertainty. By contracting with several flocks, feed suppliers were in a better position to manage uncertainties, while supplying necessary resources, because the feed supplier was concerned with *average* mortality and prices for several flocks over the entire year. These averages could be predicted with greater certainty because they varied less than the mortality rates and prices faced by an individual grower. Consequently, the feed supplier transformed a high degree of uncertainty faced by an individual grower into a smaller calculated risk (Mighell and Jones). Income uncertainty entails a cost to producers that would reduce the supply of broilers, if producers are risk averse (Knoeber and Thurman). This suggests that reductions in the cost of managing risk contributed to continual increases in broiler supplies.

Shifts in price risk and common production risk from the grower to the integrator have two basic purposes (Knoeber and Thurman). First, incentives are improved if risk is borne by the party with the greatest control over outcomes (that is, the integrator). Second, the cost of risk is reduced when borne by the party that can manage it most cheaply. Shareholders of publicly held integrators hold diversified portfolios of income-producing assets, thereby reducing the cost of risk bearing. Private companies, like Cargill, by producing a variety of products, can reduce their costs of risk bearing. Of 54 integrated broiler companies, 10 were publicly held in 1990 (Knoeber and Thurman). These 10, accounting for 53 percent of broiler production, included Tyson Foods, ConAgra, Hudson Foods, and Seaboard Corporation.

[18]Many producers are willing to accept lower payments for reductions in uncertainties about prices and production (Mighell and Jones).

[19]Uncertainty becomes even more important as asset specificity increases (Williamson; Shelanski and Klein). Increasing asset specificity related to buildings and equipment likely exacerbated the role of volatile markets in the rapid growth of production contracting and vertical integration.

Production contracts also help to reduce production uncertainties by improving technology and supervision. By providing some inputs into the production process, the integrator has stronger incentives to supervise production closely, which contributes to substantially lower mortality rates among contracted broilers (Mighell and Jones). Production contracts also facilitate the rapid adoption of new production practices because the integrator controls and supervises production on a large scale (Martin).

Vertical integration may also provide an effective means for managing market risks. Price uncertainties in hatching egg production contributed to integration of the hatchery and feed stages, as feed dealers assumed additional risk and gained greater control over production decisions.

Unlike production contracts in the broiler industry, most marketing contracts between large hog producers and processors play little role in transferring price and output risk. The packer typically provides no production inputs, and pricing formulas are typically tied to a market price, adjusted for quality. Only 4 of 27 large producers surveyed in 1994 had contracts that attempted to share or limit price risks or to link prices to hog production costs (Hayenga and others). As several of the large hog-producer integrators and large packers are publicly held or diversified, they may be proficient at managing risks.[20]

Financing Production Inputs

By reducing and shifting price and production risk, contracting can increase the flow of resources into agriculture when resource needs are significant (Mighell and Jones). Individual producers may lack the managerial ability to carry out investment opportunities, may not wish to take a chance on losing the equity in their farms, or may be unable to obtain credit from traditional sources. Production contracts often overcome these obstacles to capital investment by providing guidance and management to producers, as well as market and price guarantees. Consequently, producers are more willing to invest their own capital and labor. In addition, because their risks are reduced, they are more likely to obtain loans from lenders for buildings, equipment, and operating expenses. By reducing broiler production uncertainty through improved technology and supervision, feed supplier-integrators reduced the likelihood of major production losses. Inexperienced growers, therefore, or those with low net worth, found it easier to obtain capital from traditional lenders for buildings and equipment (Mighell and Jones).

Contracting can reduce the financial burden of each trading partner. In the broiler industry, contracting created the impetus for growers to continue production. Because of significant price and production risk, broiler growers hesitated to undertake production if they had to assemble all of the productive resources.[21] Through production contracts, larger and financially stronger feed companies reduced the growers' capital requirements by providing most of the variable inputs (chicks, feed, and medicine). At the same time, production contracts typically require the grower to make some of the investments for producing broilers (land, labor, facilities). As a result, the integrator's capital costs for plant and equipment are cut in half because the value of investments necessary for broiler processing is equivalent to the investment required for growing the birds (Westgren). This practice creates a business arrangement with mutual interests because both the integrator and growers have invested in specific fixed capital.

Costs Associated with Contracting and Integration

Milgrom and Roberts describe two types of transaction costs; those related to coordination and those related to motivation. Coordination costs include determining details of the transaction, such as prices, making buyers and sellers known to each other, and bringing buyers and sellers together to transact. Examples include

[20]In the pork industry, production contracts shift risk from the smaller growers to the large producers. Like broiler integrators, several of the large hog producers are either publicly held or are diversified into other commodities (for example, Tyson, Continental Grain, Cargill, and Dekalb, recently acquired by Monsanto), which reduces their costs of bearing risk.

[21]In some cases, even when broiler producers had the resources to produce independently, they did not wish to accept the hazards (Mighell and Jones).

costs of determining consumers' tastes and preferences, advertising, and time spent searching for suppliers offering the best prices. Motivation costs include those associated with incomplete and asymmetric information. These costs occur when there is insufficient information to determine whether terms of the transaction are acceptable and whether the terms are being met.

While contracts may be used to reduce coordination costs in open markets, there are motivation costs associated with contracting. Contracts are often incomplete because individuals are subject to unobservable outcomes or *bounded rationality*. Bounded rationality refers to an individual's limited ability to foresee all future possibilities. Contracts that account for the full range of contingencies are extremely expensive to write.

Contracts between broiler growers and integrators can create motivation costs associated with *moral hazard*. Moral hazard refers to opportunistic behavior once the contract has been entered into because actions required under the terms of the contract are not easily observable. Contracts that required the feed supplier to provide feed to the broiler grower encouraged shirking on the part of the grower. This is because the grower did not pay for the feed, and payments received by the grower did not depend on the quantity of feed used or feed efficiency. However, production contracts evolved to lower costs of moral hazard. Incentive clauses were later added that based the grower's payment on feed efficiency. Hence, the contracts controlled moral hazard and, at the same time, shifted and reduced the costs of managing price and production risk.

Contract payment methods based on relative performance were formulated to reduce costs of renegotiating contract terms in response to new technology. The rapid pace of technological advances in the broiler industry created uncertainty regarding absolute measures of efficiency that were initially specified in broiler contracts. For example, changes in technology led to unstable feed conversion ratios, which made constant absolute performance measures inefficient (Martin). Because of the integrator's bounded rationality, it became more difficult to update contract specifications to account for improvements in technology. Contract payments based on relative performance automatically adjust to technological gains. This is because the calculation of the bonus or discount would not be affected by outcomes common to all growers, such as advances in technology.[22] The reduction in the cost of revising contracts explains, in part, why broiler production remains coordinated by production contracts instead of vertical integration, despite the extreme uncertainty created by rapid changes in technology. In addition, vertical integration could lock in employee growers, whereas contracts can be established with growers who are best able to deal with changing technology.

[22]For example, contracts analyzed by Knoeber and Thurman included a settlement cost formula that was used to measure grower performance. An average settlement cost for flocks harvested at the same time was first calculated. The settlement cost would fall as feed efficiency improves, mortality rates decline, and bird weight increases. Relative performance was then measured as the difference between an individual grower's settlement cost and the average. The base payment to the grower was adjusted up (down) if the settlement cost was below (above) average.

Relationship Between Increased Vertical Coordination, Product Prices, and Quality

Current trends in food consumption include preferences for a wide variety of reliably high-quality, convenient food products available at reasonable prices. These trends have been influenced by the increasing value of households' time, reduction in household size, information linking diet and health, and greater ethnic diversity (Kinsey). Demand for convenience food products—such as take-out food, frozen entrees, and microwavable dishes—is influenced by the high value placed on time in our society. As the value of time increases, opportunity costs associated with illness and information gathering also increase. Hence, consumers increasingly prefer quality assurances, better protection from unsafe foods, and more accurate information about nutritional content. Health concerns also affect food preferences, such as the current trend toward reduced-cholesterol and reduced-fat products.

New methods of vertical coordination that improve financial opportunities, reduce the cost of managing price and production risk, and lower transaction costs can lead to increases in production efficiency, and more convenient, higher quality meat products. Changes in vertical coordination can facilitate the adoption of new cost-saving technology by reducing transaction costs and barriers to the inflow of capital. Reductions in transaction costs associated with specific investments in breeding stock, and measuring and sorting of live animals, may lead to more uniform, higher quality animals. Processing costs may decline with higher quality animals and improved scheduling of animals for slaughter.

Figure 8 illustrates potential market effects of an increase in the level of coordination. Changes in vertical coordination can reduce farm production costs and costs of marketing services, or marketing costs, which include slaughtering, processing, cutting, and merchandising. By facilitating the adoption of technological advances in farm production, the farm supply curve shifts to the right (panel a). An increase in packing plant efficiency would lower marketing costs from m=(Pr-Pf) to m'=(Pr'-Pf'), where m is marketing costs, Pr is the retail price, and Pf is the farm price (panel b). In each case, the retail supply function for meat products shifts to the right. Improvements in the quality and uniformity of live animals would increase the availability of high-quality meat products, which would shift the demand curve for meat (panel c). The change in the retail price resulting from simultaneous shifts in retail supply and demand depends on the size of the horizontal shifts and the elasticities of supply and demand. On the other hand, the equilibrium quantity is unambiguously larger. In panel d, the shift in supply from Sr to Sr' exceeds the shift in demand, from Dr to Dr', so the retail meat price falls from Pr to Pr'.[23]

Chicken Products

Changing methods of vertical coordination in the broiler industry have clearly benefited consumers of chicken products. Production contracts facilitated the adoption of new cost-reducing technology, while additional production and marketing efficiencies were obtained from vertical integration of the feed, hatchery, processing, and breeding stages. The industry has emphasized quality, variety, convenience, uniformity, and affordability in its product offerings. Consequently, retail chicken prices have fallen, while broiler supplies and per capita consumption have continued to increase. While achieving those results in the domestic market, the broiler industry has also become a net exporter of chicken meat.

Retail Prices and Supplies

The broiler industry has made remarkable gains in production and marketing efficiency. From 1975 to 1997, commercial broiler production (ready-to-cook basis) nearly quadrupled (fig. 9). After adjusting for inflation, consumers can now purchase whole broilers for

[23]Additional details concerning the relationship between vertical coordination, transaction costs, food production costs and quality, and supply and demand shifts can be found in Martinez, Smith, and Zering.

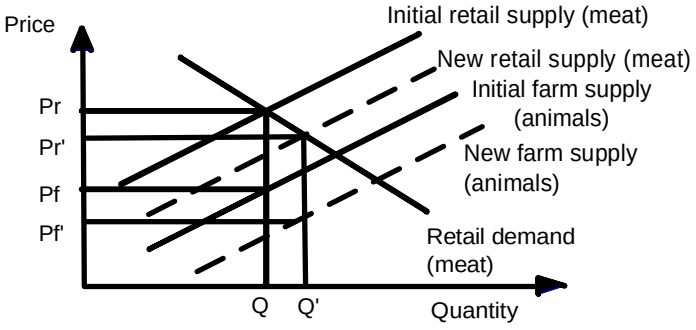
Figure 8

Potential effects of increased vertical coordination in a meat industry

Increased coordination can lower meat prices and increase meat consumption

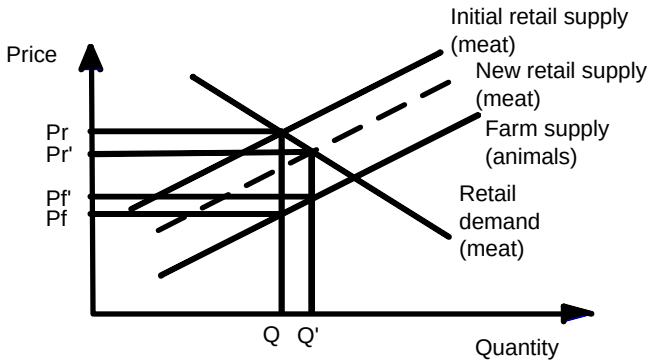
Panel a

Retail supply shift from lower farm costs



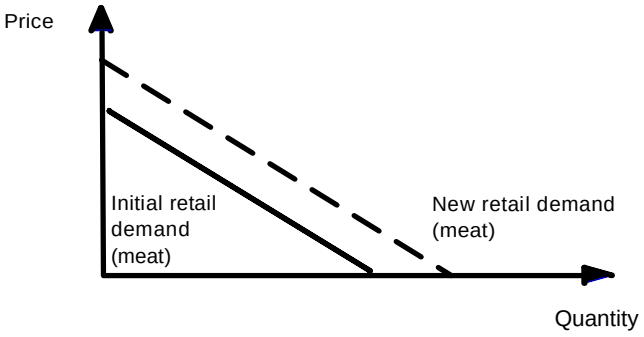
Panel b

Retail supply shift from lower marketing costs



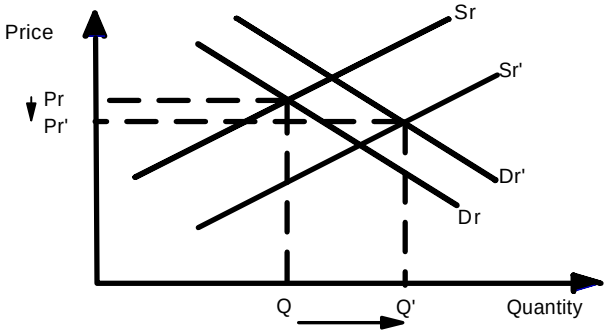
Panel c

Demand shift from quality improvement



Panel d

Net effect at the retail stage of increased vertical coordination

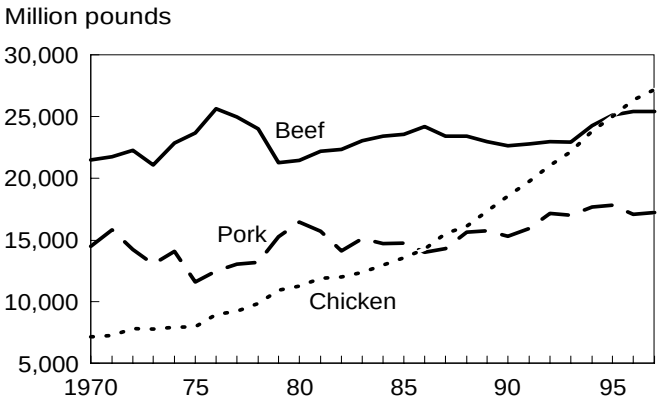


Source: ERS, USDA.

Figure 9

Total production of chicken, pork, and beef

Chicken production surpassed pork in 1986 and beef 10 years later

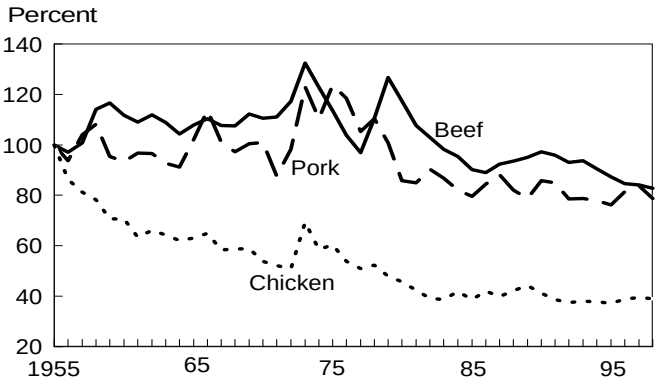


Source: ERS, USDA.

Figure 10

Deflated retail price of chicken, pork, and beef as a share of 1955 price

The real price of chicken is about 60 percent less than the price paid in 1955



Source: ERS, USDA.

less than 40 percent of what they paid in 1955 (fig. 10). After World War II, the ability to offer broilers to the emerging supermarket industry at declining *nominal* prices, while the price of many other food and meat items were increasing, played an important role in the continual growth of the broiler industry.

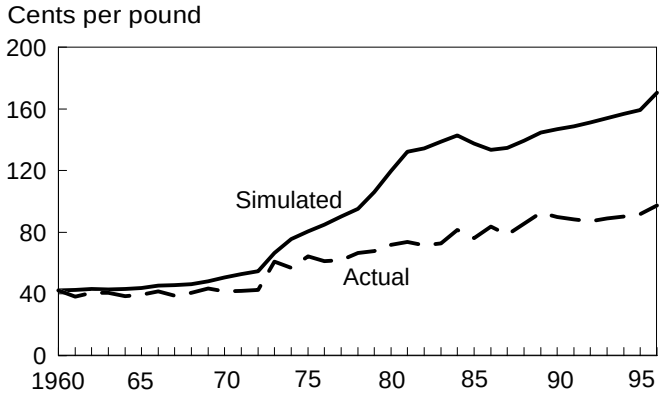
Additional evidence of the magnitude of production and marketing efficiency gains is illustrated by updating simulations conducted by Lasley. The retail price of whole broilers was simulated by holding technology and input-output relationships constant, and varying broiler production and marketing costs according to changes in input prices (see Appendix). The simulated retail price was then compared with the actual retail price to indicate productivity gains passed on to consumers (fig. 11). While the early to mid-seventies represented a period of rapidly increasing feed and energy prices, the retail price of broilers increased at a slower rate. If higher input prices had been passed on to consumers, average retail prices would have been $1.58 per pound for broilers over the 1992-96 period, instead of the actual average of 91 cents per pound.

Quality and Product Form

The U.S. broiler industry has also responded to consumer preferences for a variety of convenient, value-added products, with assurances of quality. In the mid-1960's, most broilers were sold as unbranded, homogeneous, ready-to-cook, whole birds. In response to large supplies and volatile broiler prices, integrators focused increasingly on product differentiation, through further processing and brand labeling (Bugos).[24] Fewer birds are now purchased whole; consumers prefer to purchase chicken based on selected parts or that are precooked. In the 1980's, combined sales of cut-up and further processed chicken exceeded sales of whole birds (fig. 12). By 1995, 63 percent of broiler volume was cut up and sold as parts, and 11 percent was sold as further processed products, such as chicken franks, patties, nuggets, and marinated products.

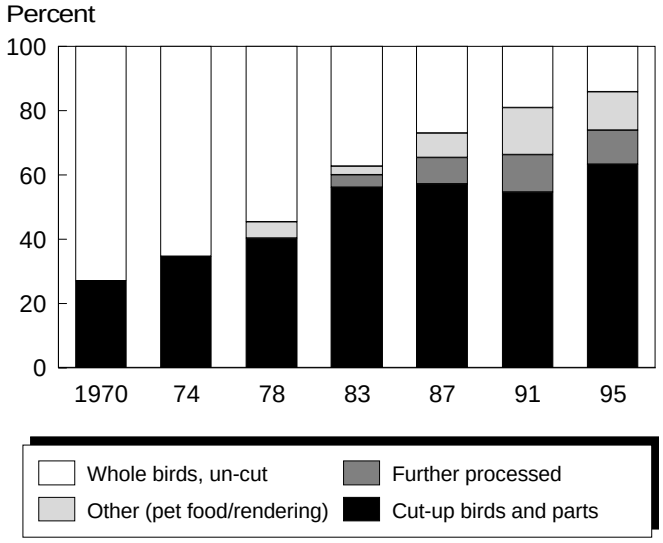
Contracting and vertical integration have given the integrator greater control over the volume and quality of broilers to meet the needs of large-scale specification buying by food-away-from-home establishments and supermarket chains. In the 10-year period follow-

Figure 11
Comparison of simulated and actual U.S. retail chicken prices
Without the adoption of new technology, consumers would be paying 75 percent more for chicken



Source: ERS, USDA.

Figure 12
U.S. processor marketing of broilers by product form
The broiler industry has responded to consumer preferences for convenient foods

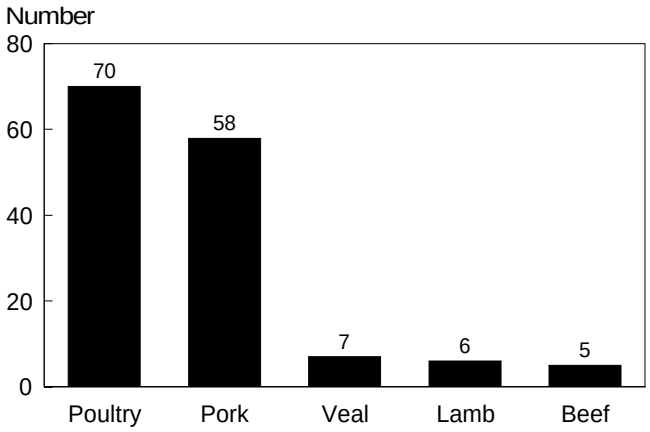


Source: Compiled by ERS, USDA from National Broiler Council [a,b].

[24]Product differentiation gives firms the ability to compete on a nonprice basis, so that earnings are less dependent on the volatile nature of undifferentiated commodity markets. Purchase decisions regarding undifferentiated products are based on prices because consumers perceive products from competing sellers to be the same. Firms gain some discretion over the price of their products by differentiating their product selection, so that sales become less sensitive to price changes.

ing 1977, approximately 25,000 fast-food outlets added chicken items to their menus (Lasley and others). Fried chicken operators preferred small and uniform broilers to control portions and costs (Marion and Arthur). The wide range of value-added chicken forms appeals to food service operators because they can spend more time individualizing their entrees and less on labor-intensive preparation and assembly (*Institutional Distribution*). The poultry industry leads the other U.S. meat industries in new product development (fig. 13). Among prepackaged, consumer-ready meat products listed by a major supermarket chain in 1996, poultry products led all other meat categories.

Figure 13
Prepackaged, consumer-ready meat products of a leading supermarket chain in 1996
The poultry industry has led the way in new product development



Source: Compiled by ERS, USDA from Brester, Schroeder, and Mintert.

Through an integrated marketing system, broiler integrators also gain control over quality and uniformity that is necessary for branded products. Branding lowers consumer costs of measuring products (Barzel). If the consumer is to purchase a product without measuring every item, the seller may attempt to convince the consumer that the purchase is representative. That is, the product is uniform and will not vary from sample to sample. Broiler integrators have standardized production inputs and have gained a large degree of control over the production process. Hence, they are willing to associate their name or brand with more uniform, high-quality products (Easterling and Stucker). In 1988, brand names accounted for half of all supermarket sales of chicken across the Nation, and shoppers were willing to pay a 14-percent premium for brand-name broilers over supermarket brands (Bugos).

While downward shifts in retail supply appear to be the dominant effect associated with increased vertical coordination in the broiler industry, demand shifts are also evident. A plot of per capita consumption of broilers and the deflated retail price provides a rough proxy of a demand curve (fig. 14). From 1955 to 1979, a strong negative relationship is indicated between the price of broilers and quantity consumed. However, the curve appears to have flattened since the 1980's. In 1982, 47 pounds of chicken per person was consumed at a price of 74 cents per pound. In 1989, per capita consumption rose to 57 pounds per person, while the price increased slightly to 75 cents per pound. Increasing per capita consumption and little or no change in price suggests the possibility of a shift out in demand.[25] Likely causes include higher relative prices of substitute meats, changing consumer tastes and preferences (for example, health concerns), and an income effect as more affluent consumers purchased premium parts and value-added products (Rogers, 1992).

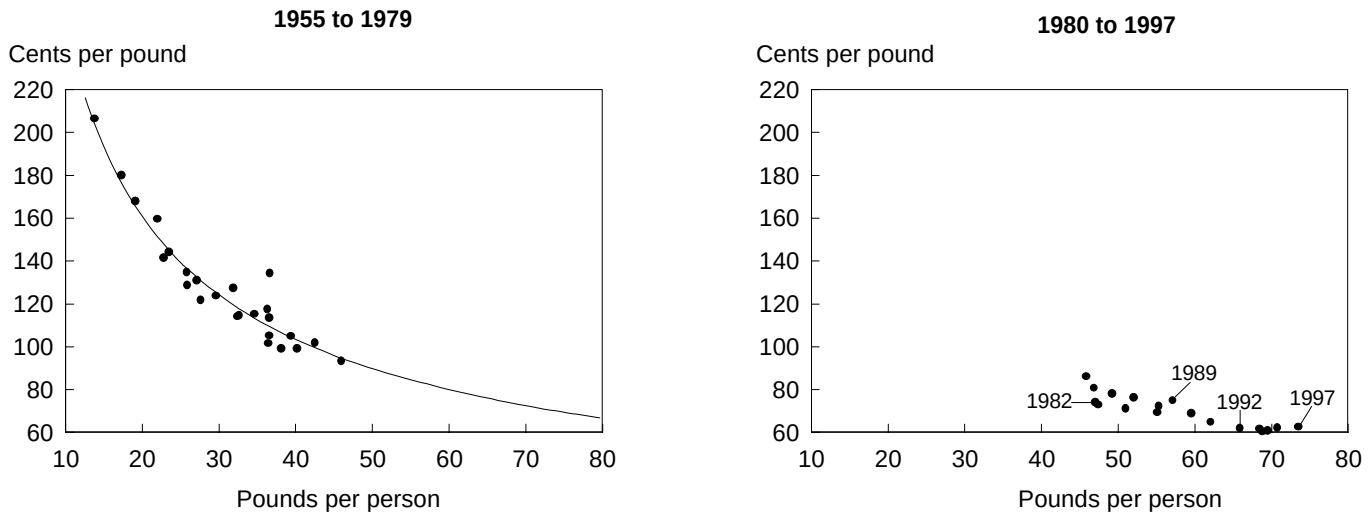
Lower prices and response to consumer preferences for convenient, nutritious, high-quality chicken products have led to continual increases in per capita broiler consumption (fig. 15). Since 1955, per capita consumption of broilers has increased more than fivefold. From 1976 to 1997, per capita broiler consumption nearly doubled, compared with a 5-percent increase for pork and a 30-percent *reduction* for beef (beef consumption peaked in 1976). In 1986, per capita consumption of broilers exceeded pork for the first time and recently surpassed beef, the leader in red meat consumption.

Pork Products

Industrialization in the pork industry has contributed to productivity gains in hog production, which have increased pork supplies and lowered pork prices. Pork quality has also become more closely associated with

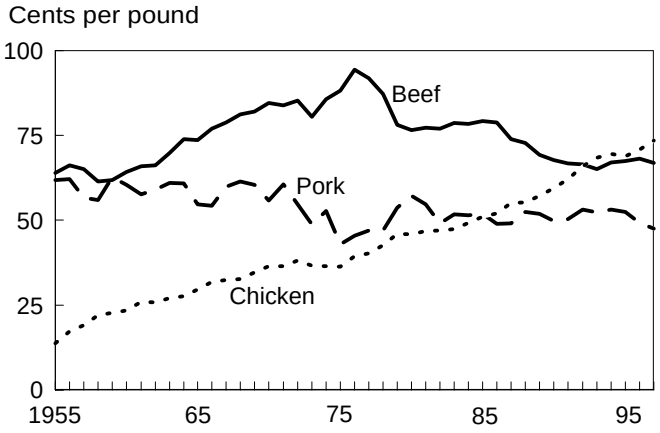
[25]A log-linear, constant elasticity relationship between price and per capita consumption is also possible, assuming that important factors other than price had no effect on demand.

Figure 14
Relationship between deflated retail broiler price and quantity consumed
Additional broiler consumption at relatively stable prices after 1980 suggests a possible shift out in broiler demand



Source: ERS, USDA.

Figure 15
Per capita consumption of pork, beef, and chicken
Per capita chicken consumption has increased more than five-fold since 1955; chicken is now the leading meat consumed in the United States



Source: ERS, USDA.

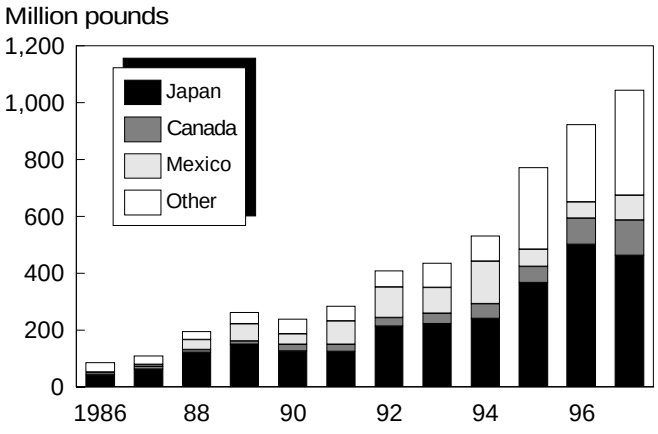
consumer preferences. The industry may realize additional economic benefits from further increases in coordination between the production and packing stages. An assured large, stable flow of uniform, high-quality hogs to the packing plant can reduce pork production costs and satisfy consumer demand for high-quality pork products.

Current Situation

Since 1990, pork production has increased by approximately 2 percent per year, increasing both total domestic consumption (accounting for population growth) and net trade. In the 1990's, U.S. pork exports have increased five-fold, and the United States has become a net exporter of pork. To satisfy export customers, pork companies must deliver reliable supplies of reasonably priced products that are tailored to customer specifications. Quality characteristics important to Japan, for example, the leading importer of U.S. pork (fig. 16), include cutting method, meat color, and lack of PSE (Cravens).

Despite a 1-percent annual average reduction in the deflated retail pork price since 1990, per capita domestic consumption (not accounting for population growth) of pork has remained stable. Unlike demand for broilers, the domestic demand for pork may have shifted to the left since the 1970's. A plot of deflated pork prices against per capita consumption provides evidence of a decrease in demand for pork (fig. 17). During 1980-97, lower pork prices brought no general increase in per capita consumption like that seen in 1955-79. For example, from 1974 to 1995 the deflated retail pork price dropped from 219 cents per pound to 128 cents per pound, with no corresponding increase

Figure 16
U.S. pork exports by destination
U.S. pork exports have increased twelve-fold since 1986; Japan is the leading importer of U.S. pork



Source: ERS, USDA.

in per capita consumption. Thurman concluded that a significant portion of demand shifts for pork may be due to factors other than relative meat prices and income, such as consumers' perception that chicken contains less fat than red meats.[26] Apparent shifts in pork and broiler demand correspond to new information linking diet and health. In 1977, the Senate Select Committee on Nutrition and Human Needs defined a set of dietary goals for the United States that helped to stimulate a deluge of research reports. Organizations, such as the National Research Council and U.S. Department of Agriculture, recommend reduced cholesterol and fat in the diet (Kinsey). In the 1980's, the American Heart Association revised its dietary guidelines to include less red meat consumption (Thurman).

Future Growth of the Pork Industry

Growth of chain restaurants and the continued importance of grocery store outlets provide opportunities to cater to changing consumer preferences. Satisfying the needs of large chain restaurants requires large, uniform pork supplies. Introduction of bacon-topped sandwiches by hamburger chains, for example, created a new outlet for millions of pounds of bacon.

[26]Thurman found no evidence to support the assumption that increased eating away from home decreases the own-price elasticity of pork.

Quality assurances are also required for branded products at retail chains, foodservice institutions, and international markets. While most red meat is unbranded, except for processed products like sausage, ham, and bacon, new products, like Smithfield Foods' *Lean Generation* brand of lean, fresh pork products, provide brand name quality assurances for consumers.

Smithfield Foods emphasizes the importance of long-term contracts and vertical integration in obtaining a consistent supply of high-quality hogs (Smithfield Foods, Inc.). Smithfield Foods has long-term contracts with affiliates of Carroll's Foods, a major North Carolina hog producer, to raise and purchase hogs. In 1991, this arrangement, referred to as Smithfield-Carroll's, acquired the exclusive franchise rights from the National Pig Development (NPD) Company, a British firm, to develop and market the NPD breed of hog in the United States. This breed is said to provide the leanest hog in U.S. commercial production and one of the leanest meats of any kind. Nutritional studies by the Sarah W. Stedman Center for Nutritional Studies at Duke University Medical Center in 1996 indicated that NPD pork was 34 percent to 61 percent leaner than non-NPD pork, depending on the cut. Products under the Smithfield *Lean Generation* label are the only pork products that have received the American Heart Association's seal of approval because of the products' superior health qualities. An NPD hog also produces about 15 pounds of additional salable meat per hog (Credit Suisse First Boston Corporation).

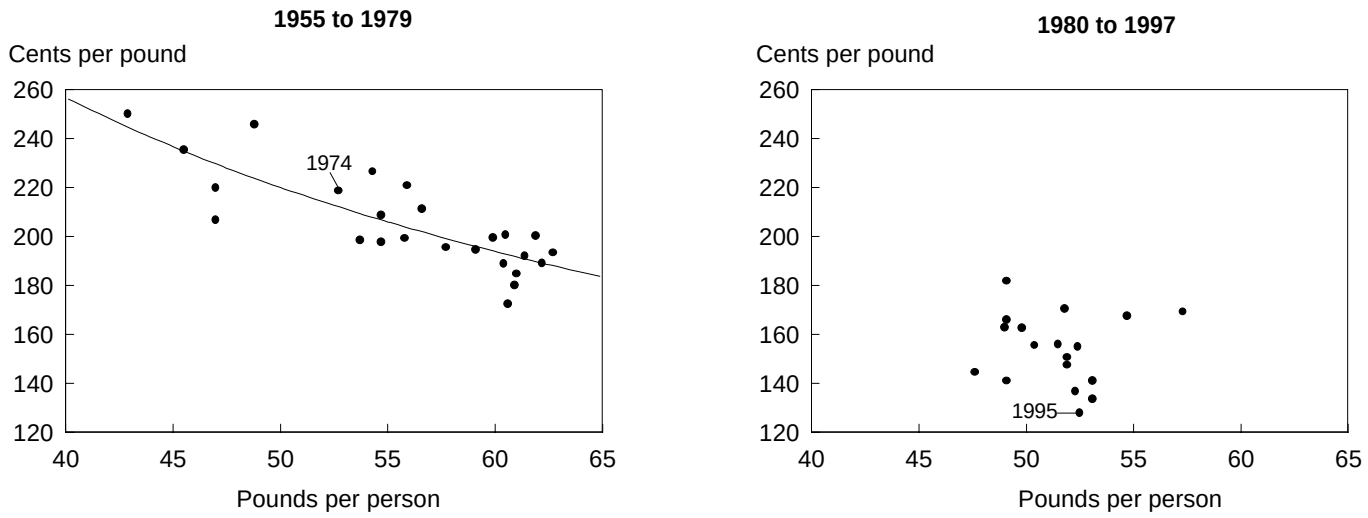
Smithfield's *Lean Generation* pork has been successful so far. The number of NPD hogs processed by Smithfield grew from 12,700 in 1993 (Smithfield Foods, Inc.) to 1.6 million in 1997 (Smithfield Foods, Form 10K, filed with Securities and Exchange Commission July 25, 1997). Through an agreement with Sumitomo Corporation, Smithfield also provides the Japanese market with a line of branded fresh pork products.

While some companies have made great strides in improving the quality of pork products, much still needs to be done to attain consistently high-quality pork. A 1992 survey of U.S. pork packing companies, representing 70 percent of total slaughter, found that quality problems cost packers $10.08 per hog due to excess fat, PSE, and carcass defects, such as abscesses

Figure 17

Relationship between deflated retail pork price and quantity consumed

Pork prices fell by nearly 42 percent from 1974 to 1995 with no corresponding increase in consumption



Source: ERS, USDA.

and bruises (table 1). For example, carcass defects and excess fat must be removed, which results in less salable meat. PSE problems cause pork cuts best suited for fresh pork to be used in further processed pork.

Increasing coordination between packers and producers to improve pork quality may yield packer cost savings and larger quantities of consistent, high-quality pork products. Of the total packer costs related to quality problems, $8.15 (80 percent of total problem cost) was controllable by actions at the farm level. By reducing improper injections of medication and rough handling of hogs, which cause abscesses and bruising, farmers can lower packer costs related to carcass defects. Leanness problems and PSE problems can be controlled by farmers through improved genetics. Availability of higher quality pork might also increase pork demand, by giving consumers a lean, yet palatable, pork product with a more attractive appearance.

Table 1—Packer costs associated with quality problems

Packer defect	Cost	Cost controlled by farmer	
	$/head	Percent	$/head[1]
Leanness problems:			
Backfat thickness	2.80	100	2.80
Degree of ham and butt trimming	1.87	100	1.87
Excessive seam fat	.63	100	.63
Bellies too fat or too thin	.14	100	.14
Weight problems	.88	100	.88
Carcass problems:			
Carcass condemnations	1.00	75	.75
Abscesses	.47	100	.47
Bruises	.08	75	.06
Skin problems	.01	75	.0075
Arthritis	.08	100	.08
Other	1.29	0	0
PSE/color problems:			
Color	.27	75	.20
Pale, soft, watery	.34	75	.25
Dark, firm, dry	.01	75	.0075
Total packer costs	10.08		8.15

[1]Calculated by multiplying cost per head and percent of cost controlled by farmer.

Source: National Pork Producers Council, 1994.

Policy Responses to New Methods of Vertical Coordination

Perfectly competitive markets provide an ideal standard against which one can compare actual market behavior. The theory underlying perfect competition assumes that there is a large number of independent producers and consumers (so that no individual can influence prices), firms can freely enter and exit the industry, and producers and consumers have perfect information about prices and the quality of goods. In a perfectly competitive market, entrepreneurial actions of independent sellers and buyers will yield an equilibrium price and quantity that maximizes aggregate economic welfare of producers and consumers.

Firms with market power can influence prices to their benefit, so that prices and resource allocations are no longer representative of a competitive equilibrium.[27] When market prices do not convey proper signals, producers and consumers are not able to make profit-maximizing or utility-maximizing decisions.

Firms may vertically integrate to enhance market power by limiting entry into existing markets or by expanding their influence.[28] According to Mighell and Jones, large horizontal size serves as the original means for market power, which can then be enhanced by vertical integration. Firms may continue to grow beyond what is needed to capture scale economies, to increase their influence on adjoining stages. Some firms may try to limit competition by excluding competitors from certain areas or by reducing available markets. Firms can achieve similar market power-enhancing results with less capital investment through use of contracts, even though contracts are specified for only a limited time.

As open market coordination is replaced by contracts or vertical integration, market prices may become less representative of competitive equilibrium supply and demand conditions because they are based on fewer purchases and sales. They may also become highly volatile and subject to manipulation. These markets are commonly referred to as *thin markets*. Price signals in thin markets may lead to misallocated resources and lower social welfare relative to the standard of perfect competition.

Concerns about market power stemming from the rapid structural changes in the pork and other red meat industries prompted funding for a USDA study on concentration in the red meat industries. The study found a continual need to monitor and analyze structural change in the industries (USDA[i]). A USDA advisory committee, formed later to analyze the concentration study and other relevant studies (USDA[h]), suggested that the public role may be one of ensuring that negotiating parties are well informed of market conditions, and establishing penalties for exploitative behavior. In 1997, USDA expressed its intent to strengthen fair trade practices, including an investigation of pricing and procurement methods, procurement areas, and contractual agreements by several major hog slaughter plants.[29]

Contracting arrangements between hog producers and packers have been an area of focus because of the substantial increases in these arrangements. Smaller independent hog producers complain they cannot compete when large packers contract only with large producers and do not make public the premiums they pay. In addition, an increasing share of hogs is being sold through marketing contracts that include formula pricing. For example, marketing contracts between producers and packers in North Carolina include a formula for pricing the hogs based on the Midwest quoted price adjusted for quality premiums or discounts. With fewer sales based on negotiated prices by large numbers of buyers and

[27]"Market power" refers to the ability of firms to influence price and other terms of trade.

[28]A recent example is Tyson's acquisition of the Cobb Company to prevent competitors from monopolizing the Cobb 500 strain of birds (Bugos).

[29]USDA is also examining potential anticompetitive practices in poultry procurement, including the effects of production contracts on broiler growers.

sellers (thin markets), the prices may become less representative of a competitive market equilibrium.

The commercial broiler industry faced changes in vertical coordination years ago. Yet, the industry has been relatively free of government intervention. Before 1961, government's role in the broiler business was that of "helpful, but benign, mentor and aid to the industry" (Tobin and Arthur, p. 83). By 1961, there was increased interest by policymakers in dealing with problems faced by producers, namely broiler price depressions and market volatility. There were failed attempts by the Kennedy Administration, for example, to support prices and regulate production to "stabilize" the industry. There appears to have been less concern about the nature of competition.[30] Any market advantage potential in the broiler industry may have been disguised by the rapid changes that occurred. More significant factors may have been new technology, rapid growth in production, and expanded market demand (Mighell and Jones). In addition, the broiler industry has been one of the least concentrated industries in the food system (Rogers, 1992).[31] Moreover, there had never been a large core of independent broiler producers, as in the pork industry, so price discrimination and a decline in the number of market outlets were less important issues.

[30]Potential problems associated with contracting and vertically integrated structures were certainly recognized. In a 1966 report by the National Commission on Food Marketing (NCFM), issues were summarized regarding the accuracy and representativeness of the base used in formula pricing arrangements between buyers and sellers, and the quality of market information. In addition, the National Broiler Marketing Association, which was a cooperative formed by broiler integrators in 1970 to promote market stability, was found to be in violation of antitrust regulations and was later disbanded as an illegal conspiracy (Alden Manchester, ERS, contributed this point).

[31]Economic theory suggests that in markets characterized by imperfect competition (monopoly, monopsony, oligopoly), firms may contract or vertically integrate to increase profits. In most cases considered by Royer, however, vertical integration increased output, lowered consumer prices, and increased social welfare.

Summary and Conclusions

The U.S. broiler industry provides an excellent demonstration of the importance of vertical coordination on food system performance. While several possible motives exist for contracting and vertical integration, these methods of coordination clearly facilitated substantial reductions in the retail price of broilers (table 2). Although technological advances in the 1940's and 1950's set the stage for growth and development of the broiler industry, the manner in which the industry was organized prevented its making best use of this technology. New methods of organizing broiler production facilitated the rapid and thorough adoption of new cost-lowering production technology. Contracts between the broiler growers and feed company-integrators became a means of quickly harnessing new technology by reducing capital constraints.

By facilitating adoption of new technology, improving risk management, and stabilizing flows of uniform broiler supplies into processing plants, these arrangements provided the means for lowering production costs, increasing production, lowering retail prices, and controlling quality. Following World War II, while broiler production and consumption expanded at a rapid pace, supplies and prices were highly variable. Production contracts between broiler growers and integrators improved production practices and transferred price and production risk to the integrators, who could manage the risk more cheaply. Vertical integration of the feed, hatchery, and processing stages enabled firms to maintain large volumes and control the flow of broilers at each stage to capture economies of scale. Contracting and vertical integration, from breeding to processing, also enabled broiler integrators to standardize production inputs and gain a large degree of control over the production process. That control has enabled the industry to provide uniform, high-quality broilers for further processing and branding.

Rapid changes in methods of vertical coordination in the pork industry are also associated with new technology, substantial growth in new geographical areas of production, and scale economies. The motives for changing to new methods of vertical coordination seem to be similar in both industries. Contractual agreements and vertical integration are associated with specific assets, quality control, and assurances of stable input flows and market outlets. By reducing the likelihood of opportunistic behavior associated with specific assets, larger investments may be made in cost-reducing and quality-improving technology. Contracting and integration may also facilitate

Table 2—Implications of changing methods of vertical coordination for meat products

Incentive	Outcome	Effect on meat products
Capital inflow from financially stronger firms	Facilitate adoption of new technology	Lower production costs, larger supplies, lower prices, improved quality
Shift risk-management responsibilities to more capable, technically proficient firms	Lower costs of managing price and production risks	Larger supplies, lower prices
Lower measuring and sorting costs	Improved animal quality and uniformity	Lower production costs, improved quality, convenience
Assure input supplies and market outlets	More stable input flows and lower production risk	Lower procurement and processing costs, larger supplies, lower prices
Gain market power	Increased profits	Ambiguous

improvements in meat quality by lowering measuring and sorting costs to assure high-quality animals. With large, stable flows of uniform animal supplies, processing plants can operate near optimum capacity, thereby keeping processing costs low.

While recent developments in the pork industry have increased pork supplies, lowered retail pork prices, and improved pork quality, the need to further improve the quality and consistency of pork products may accelerate the use of contractual arrangements and vertical integration. New entrants into packing in the 1990's have included a number of single-plant firms, emphasizing value-added, differentiated pork products in order to compete with the higher volume, lower cost, multi-plant firms (Boehlje and others). Firms such as Premium Standard Farms (PSF) and Seaboard Corp. stress highly coordinated raw material flows and close alliances with their customers.

Throughout the development of the broiler industry, the government's approach was basically *laissez-faire*. While concerns were raised about price discrimination and thin markets associated with increases in contracting and vertical integration, few instances of antitrust prosecution occurred, and no restrictions were placed on new methods of coordination. When open markets fail to satisfy the ideals of perfectly competitive markets, firms may seek alternatives to open market coordination. For example, in the early years of broiler industry development, large capital requirements provided significant barriers for broiler growers. Contractual arrangements with feed dealers reduced the growers' financial burden and facilitated the adoption of new cost-saving technology. As the marketing system adjusted to coordinate production with consumer demand, consumers were the major beneficiaries.

Economic incentives for new methods of coordination, and possible benefits to consumers, should also be considered when addressing issues of market power and environmental degradation related to large hog and packing operations. Public policies that limit structural changes in the pork industry may reduce benefits related to size economies and increased vertical coordination.

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Simulations of Retail Broiler Prices Assuming Input Price Increases Are Passed on to Consumers

Simulated retail chicken prices were calculated by summing the simulated farm value of broilers (ready-to-cook basis (RTC)) in year j (FV_j) and simulated broiler marketing costs in year j (MC_j). Farm value in each year was simulated by using price indices for production inputs to adjust feed cost, nonfeed cost, and returns to producers in 1960, and then summing across inputs:[1]

$$FV_j = \frac{FEED\left(\frac{FPI_j}{FPI_{1960}}\right) + NONFEED\left(\frac{PPI_j}{PPI_{1960}}\right) + RETURNS\left(\frac{CPI_j}{CPI_{1960}}\right)}{.72} \quad (1)$$

where FEED is the feed cost per pound of broilers in 1960 (10.3 cents per pound), FPI_j is the broiler feed price index in year j, NONFEED is the nonfeed production costs in 1960 (5.4 cents per pound), PPI_j is the producer price index for finished goods in year j, RETURNS are the returns to producers above production costs in 1960 (1.1 cents per pound), and CPI_j is the consumer price index in year j. Returns were multiplied by the Consumer Price Index to calculate the returns in year j that would have provided the same real return as 1.1 cents in 1960. Live weight farm value was then divided by 0.72 to convert to RTC basis. Similarly, marketing costs were simulated by multiplying broiler marketing costs in 1960 by the appropriate price indices, and summing:

$$MC_j = LABOR\left(\frac{EARN_j}{EARN_{1960}}\right) + ENERGY\left(\frac{FUEL_j}{FUEL_{1960}}\right) + PACK\left(\frac{CONTAIN_j}{CONTAIN_{1960}}\right) + OVERHD\left(\frac{PPI_j}{PPI_{1960}}\right) \quad (2)$$

where LABOR is the broiler labor marketing cost in 1960 (8.1 cents per pound), $EARN_j$ is the index of average hourly earnings of production workers in the food and kindred products industries in year j, ENERGY is energy cost in 1960 (1.6 cents per pound), $FUEL_j$ is the index for fuels, power, and related products, PACK is the packaging and materials cost in 1960 (1.6 cents per pound), $CONTAIN_j$ is the index of prices for containers in year j, and OVERHD are overhead and other costs in 1960 (7.7 cents per pound).

[1]According to Lasley, benchmark data were available for this year and prices were relatively stable, even though major industry changes had already begun.

Appendix table 1—Consumer price indices and indices for production inputs

Year	CPI food [1]	Broiler rations [2]	PPI finished goods [3]	Marketing cost indices[4]		
				Labor---Hourly earnings and benefits	Fuel and power	Packaging and containers
	1982-84=100	1980=100	1982=100	1967=100		
1960	29.6	44.6	33.4	79.9	96.1	95.5
1961	29.9	45.0	33.4	82.2	97.1	94.7
1962	30.2	45.1	33.5	84.7	96.6	95.9
1963	30.6	44.1	33.4	87.1	96.3	94.7
1964	31.0	44.0	33.5	89.8	93.7	94.0
1965	31.5	44.1	34.1	91.9	95.5	95.8
1966	32.4	45.6	35.2	95.4	97.8	98.4
1967	33.4	45.0	35.6	100.0	100.0	100.0
1968	34.8	42.9	36.6	106.5	99.7	96.3
1969	36.7	43.6	38.0	113.7	100.5	99.5
1970	38.8	46.1	39.3	122.5	106.1	103.6
1971	40.5	47.3	40.5	131.9	112.3	106.6
1972	41.8	47.5	41.8	143.3	118.4	110.4
1973	44.4	73.4	45.6	154.2	133.1	117.3
1974	49.3	81.6	52.5	168.7	198.9	149.7
1975	53.8	79.1	58.2	187.4	236.1	174.4
1976	56.9	81.4	60.8	203.8	264.5	184.8
1977	60.6	82.6	64.7	222.4	310.6	192.8
1978	65.2	81.7	69.8	244.4	331.7	204.7
1979	72.6	91.5	77.6	265.8	418.2	228.4
1980	82.4	100.0	88.0	292.6	563.2	261.5
1981	90.9	109.9	96.1	321.3	669.2	280.9
1982	96.5	101.6	100.0	342.7	705.1	275.1
1983	99.6	107.7	101.6	356.8	705.1	280.7
1984	103.9	112.8	103.7	365.5	712.5	303.5
1985	107.6	95.2	104.6	363.0	700.0	312.1
1986	109.6	90.5	103.2	359.4	590.2	317.4
1987	113.6	89.7	105.2	361.2	596.7	329.8
1988	118.3	96.1	108.0	370.5	578.2	350.7
1989	124.0	97.5	113.6	382.2	619.4	364.6
1990	130.7	87.7	119.2	395.7	671.4	367.6
1991	136.2	87.7	121.7	405.8	655.7	371.2
1992	140.3	88.0	123.2	418.4	654.6	370.1
1993	144.5	88.5	124.7	432.1	671.7	371.1
1994	148.2	92.2	125.5	443.6	660.7	385.3
1995	152.4	91.5	127.9	455.2	633.7	415.7
1996	156.9	118.1	131.3	459.7	670.7	399.8

[1]Source: U.S. Department of Labor, Bureau of Labor Statistics.

[2]Source: Lasley and others and U.S. Department of Labor, Bureau of Labor Statistics.

[3]Source: U.S. Department of Labor, Bureau of Labor Statistics.

[4]Source: Elitzak; Lasley.

Appendix table 2—Simulated costs of producing live broilers

Year				Farm value	
	Feed	Nonfeed	Returns	Liveweight	Ready-to-cook
			Cents/pound		
1960	10.3	5.4	1.1	16.8	23.3
1961	10.4	5.4	1.1	16.9	23.5
1962	10.4	5.4	1.1	17.0	23.5
1963	10.2	5.4	1.1	16.7	23.2
1964	10.2	5.4	1.2	16.7	23.2
1965	10.2	5.5	1.2	16.9	23.4
1966	10.5	5.7	1.2	17.4	24.2
1967	10.4	5.8	1.2	17.4	24.1
1968	9.9	5.9	1.3	17.1	23.8
1969	10.1	6.1	1.4	17.6	24.4
1970	10.6	6.4	1.4	18.4	25.6
1971	10.9	6.6	1.5	19.0	26.3
1972	11.0	6.8	1.6	19.3	26.8
1973	16.9	7.4	1.7	26.0	36.1
1974	18.8	8.5	1.8	29.2	40.5
1975	18.3	9.4	2.0	29.7	41.2
1976	18.8	9.8	2.1	30.7	42.7
1977	19.1	10.5	2.3	31.8	44.1
1978	18.9	11.3	2.4	32.6	45.2
1979	21.1	12.5	2.7	36.4	50.5
1980	23.1	14.2	3.1	40.4	56.1
1981	25.4	15.5	3.4	44.3	61.5
1982	23.4	16.2	3.6	43.2	60.0
1983	24.9	16.4	3.7	45.0	62.5
1984	26.0	16.8	3.9	46.7	64.8
1985	22.0	16.9	4.0	42.9	59.6
1986	20.9	16.7	4.1	41.6	57.8
1987	20.7	17.0	4.2	41.9	58.3
1988	22.2	17.5	4.4	44.0	61.2
1989	22.5	18.4	4.6	45.5	63.2
1990	20.2	19.3	4.9	44.4	61.6
1991	20.2	19.7	5.1	45.0	62.5
1992	20.3	19.9	5.2	45.5	63.1
1993	20.4	20.2	5.4	46.0	63.8
1994	21.3	20.3	5.5	47.1	65.4
1995	21.1	20.7	5.7	47.5	65.9
1996	27.3	21.2	5.8	54.3	75.5

Source: ERS/USDA.

Appendix table 3—Simulated marketing costs and retail prices

Year	Marketing costs[1]						
	Labor	Energy	Packaging and material	Overhead and other	Total marketing costs	Simulated retail price[1]	Actual retail price[2]
				Cents/pound			
1960	8.1	1.6	1.6	7.7	19.0	42.3	42.4
1961	8.3	1.6	1.6	7.7	19.2	42.7	38.3
1962	8.6	1.6	1.6	7.7	19.5	43.1	40.5
1963	8.8	1.6	1.6	7.7	19.7	42.9	40.8
1964	9.1	1.6	1.6	7.7	20.0	43.2	38.6
1965	9.3	1.6	1.6	7.9	20.4	43.8	39.6
1966	9.7	1.6	1.6	8.1	21.1	45.3	41.6
1967	10.1	1.7	1.7	8.2	21.7	45.8	38.7
1968	10.8	1.7	1.6	8.4	22.5	46.3	40.8
1969	11.5	1.7	1.7	8.8	23.6	48.1	43.4
1970	12.4	1.8	1.7	9.1	25.0	50.6	41.7
1971	13.4	1.9	1.8	9.3	26.4	52.7	42.0
1972	14.5	2.0	1.8	9.6	28.0	54.8	42.7
1973	15.6	2.2	2.0	10.5	30.3	66.4	60.8
1974	17.1	3.3	2.5	12.1	35.1	75.6	57.0
1975	19.0	3.9	2.9	13.4	39.3	80.5	64.3
1976	20.7	4.4	3.1	14.0	42.2	84.9	61.2
1977	22.6	5.2	3.2	14.9	45.9	90.0	61.9
1978	24.8	5.5	3.4	16.1	49.8	95.1	66.5
1979	27.0	7.0	3.8	17.9	55.6	106.2	67.7
1980	29.7	9.4	4.4	20.3	63.7	119.8	71.9
1981	32.6	11.1	4.7	22.2	70.6	132.1	73.7
1982	34.8	11.7	4.6	23.1	74.2	134.2	71.6
1983	36.2	11.7	4.7	23.4	76.1	138.6	72.8
1984	37.1	11.9	5.1	23.9	77.9	142.8	81.4
1985	36.8	11.7	5.2	24.1	77.8	137.4	76.3
1986	36.4	9.8	5.3	23.8	75.4	133.2	83.5
1987	36.6	9.9	5.5	24.3	76.4	134.6	78.5
1988	37.6	9.6	5.9	24.9	78.0	139.2	85.4
1989	38.8	10.3	6.1	26.2	81.4	144.6	92.7
1990	40.1	11.2	6.2	27.5	85.0	146.6	89.9
1991	41.2	10.9	6.2	28.1	86.4	148.9	88.1
1992	42.4	10.9	6.2	28.4	88.0	151.1	86.9
1993	43.8	11.2	6.2	28.8	90.0	153.8	89.0
1994	45.0	11.0	6.5	28.9	91.4	156.8	90.1
1995	46.2	10.6	7.0	29.5	93.2	159.1	91.7
1996	46.6	11.2	6.7	30.3	94.8	170.2	97.3

[1]Source: ERS/USDA.

[2]Source: Lasley and others and USDA[c].