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Vertical Coordination of Marketing Systems: Lessons From the Poultry, Egg, and Pork Industries

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Abstract

The poultry, egg, and pork industries have taken significant steps to improve the control of production either through contracting and/or vertical integration. These improved controls were motivated by the emergence of new specialized large-scale production technologies that placed a premium on quality control and the efficient use of information. The heightened speed of production, the perishable nature of products, and significant measuring and sorting costs all increased the difficulty of obtaining accurate economic information and thereby increased the cost of exchange throughout the marketing system. Contracts and vertical coordination provided an efficient means of organizing markets by reducing these transaction costs.

Keywords: Vertical coordination, vertical integration, contracts, transaction cost economics, technology, measuring and sorting costs, poultry, pork.

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Summary

The U.S. poultry, egg, and pork industries each have experienced increases in contracting and vertical integration. Changes occurred decades ago in the poultry and egg industries and have occurred more recently in the pork industry. Production contracting grew quickly in the broiler industry, and nearly all broilers now are produced under production contracts between processors and growers. While production contracts also became more prevalent in the turkey and egg industries, vertical integration also became more common. In the pork industry, marketing contracts became more popular, although packer ownership of hogs also has risen in more recent years.

In each of the industries, spot markets apparently became a less efficient means of coordinating production and processing. This effect may be explained by higher transaction costs from a variety of sources. First, several developments in each of the industries led to higher costs associated with safeguarding investments. Each of the industries underwent periods in which they adopted new specialized technologies and experienced associated scale economies. These developments led to investments with few alternative uses and few alternative users, or relationship-specific investments, particularly in regions of expanding production. Such investments leave trading partners vulnerable to opportunistic behavior by other parties seeking a more favorable position in the relationship.

Other factors also created value in continuing relationships between specific trading partners. For example, in the poultry and egg industries, farms and processing units located close to each other. Short distances between trading partners resulted in more relationship-specific transactions—trading partners separated by longer distances would result in higher transportation costs. Also, poultry and eggs are perishable products that require timely delivery from the farm to the processing plant. This factor makes producers highly vulnerable to tactics used by processors to delay acceptance of products to obtain a more favorable deal, as it may be difficult for producers to find alternative processors before the products perish.

Contracting and vertical integration provided a means for reducing transaction costs associated with relationship-specific transactions, especially in regions of expanding production. Contracts could provide some safeguards to protect against opportunistic behavior, and vertical integration eliminated the exchange relationship altogether.

Contracts and vertical integration also may facilitate reductions in product measuring and sorting costs, leaving more gains from trade to be distributed among producers and consumers. For product attributes that are difficult to measure, gaining additional control over related production inputs may reduce measuring costs by reducing the need to measure quality. Similarly, by controlling inputs that result in more uniform product attributes, measuring and sorting costs may be reduced because there is no need to measure every product. Controlling production inputs facilitates branding programs that transfer measuring and sorting costs from consumers to the food supply system. The poultry industry has been especially successful with branding programs, and the pork industry is increasing its use of branding strategies.

Relationship-specific transactions and uncertain market conditions also may explain differences in methods of vertical coordination found in the poultry, egg, and pork markets. As transactions become more relationship-specific, vertical integration will become more prevalent. Greater uncertainty related to consumer preferences, production, or income make it more important for firms to find ways to adapt. Consequently, vertical integration and contracts that give the contractor more control over the producer or that respond automatically to changing conditions will become more common.

In addition to reducing transaction costs, contracts and vertical integration may influence production decisions that result in more efficient resource allocations. This effect is demonstrated by substantial gains in production efficiency in each of the three industries and development of high-quality, consistent consumer products. Considering both reductions in transaction costs and benefit effects would provide a more complete framework for analyzing the organization of agricultural markets.

Introduction

Vertical coordination of the broiler, turkey, and egg industries changed significantly decades ago. In the broiler industry, production contracts between feed companies/contractors and growers accounted for over 85 percent of production in 1955, as fewer growers operated independently. These contracts later evolved, giving more control to the contractors. In the 1960s, relationships between the production and processing stages also changed, as feed companies became more directly involved in both broiler production and processing. In the 1970s, many feed companies exited the broiler business, leaving processors as the major contractors with growers. Since the 1950s, the prevalence of production contracts in the broiler industry has been stable.

In the turkey and egg industries, contracting developed at a slower rate than in the broiler industry, but vertical integration was more common. In vertically integrated operations, a single firm conducts production and processing. Initially, feed dealers entered production contracts with egg and turkey producers. In 1955, 21 percent of turkeys were produced under production contracts, and 4 percent were produced in vertically integrated operations. By 1977, production contracts accounted for 52 percent of production, and vertical integration had increased to 28 percent of production. In 1955, only 2 percent of table eggs were produced under production contracts or vertically integrated operations. By 1977, production contracts and vertically integrated operations accounted for 44 and 37 percent of table egg production, respectively. Over this period, production contracts in the egg and turkey industries evolved to transfer more price and production risk from growers to contractors, and processors assumed the role of contractor. Today, production contracts, together with vertical integration, account for over 90 percent of production in each of the three industries.

Coordinating arrangements in the turkey and egg industries have received less scrutiny than arrangements in the broiler industry, perhaps due to the smaller size and level of growth of the turkey and egg industries. In 1999, broilers represented 68 percent of the estimated farm value of U.S. poultry and egg sales, compared with 19 percent for eggs and 13 percent for turkeys (USDA[c]). However, despite these differences, a comparison of the structural changes in each of the three industries may provide useful insights into other agricultural industries that are undergoing changes in vertical coordination.

More recently, the U.S. pork industry also has undergone significant changes in vertical coordination, as contracting has surged. From 1993 to 2001, hogs sold through contractual arrangements increased in share of total hogs sold from 10 to 72 percent. Consequently, sales and purchases through the traditional spot, or open, markets have dwindled to 28 percent.

This report examines possible motives for changes in vertical coordination of the poultry, egg, and pork industries. In the broiler industry, production contracts and vertical integration facilitated rapid growth of the industry through gains in production efficiency and response to consumer preferences for convenient, nutritious products (Martinez, 1999). To what extent is the broiler industry unique in its motives for contracting and vertical integration? What are the common characteristics of the poultry, egg, and pork industries that explain such a large degree of contracting and vertical integration? Why are there differences in the use of contracting and vertical integration in the otherwise similar poultry and egg industries? What insights do such comparisons bring to industries that are currently undergoing dramatic structural changes, such as the pork industry? This report attempts to answer these questions by extending concepts from transaction cost economics.

Evolution of Vertical Coordination in the Poultry, Egg, and Pork Industries

Vertical coordination refers to the synchronization of successive stages of production and marketing, with respect to quantity, quality, and timing of product flows. Methods of vertical coordination include open production (also referred to as open, or spot, market), contract production, and vertical integration. In open production, a firm does not commit to selling its output before completing production. Cash (or spot) prices coordinate resource transfer across the stages of production. Contract production is the production of goods and services for future delivery. Before completing production, a producer commits to deliver a particular good to a particular buyer. Contract production involves more interaction between buyers and sellers than open production. Production contracts vary in control allocated and risk transferred across stages. In *market-specific production contracts*, the contractor and producer may negotiate delivery schedule, pricing method, and product characteristics. The contractor usually provides a market for the goods but engages in few of the producer's decisions.¹ In *resource-providing contracts*, the contractor provides a market for the goods, engages in many of the producer's decisions, and retains ownership of important production inputs. While this classification scheme is not unique, it provides a general framework for contract terminology (Martinez and Reed).²

In vertical integration, a single firm controls two or more successive stages of vertical coordination. In vertically integrated firms, management directives dictate the transfer of resources across stages.

Movement along the continuum of vertical coordination from open-market production to vertical integration represents the degree to which control of production has shifted to the contractor or integrator as more functions are transferred from the producer (fig. 1).

¹The contractor in an exchange relationship is the firm that controls several stages of production and marketing through contracts. In this report, the term "integrator" is reserved for a firm that controls several stages through vertical integration.

²In their ground-breaking 1963 study, Mighell and Jones also include *production-management contracts* in their categorization of production contracts. These contracts are similar to market-specific contracts but give contractors more direct involvement in production decisions.

Figure 1

Methods of vertical coordination along the spectrum of control



Source: Mighell and Jones.

While market-specific production contracts, often referred to as marketing contracts, provide contractors with more control than open-market coordination, the control transferred across stages is usually minimal.

Vertical Coordination in the Poultry and Egg Industries

In the mid-1900s, poultry and egg firms specialized in certain activities, and spot markets were the dominant means of vertical coordination (app. A). Feed was produced in commercial feed mills. Poultry and eggs were sold to slaughter plants and egg-handling facilities that performed many of the marketing functions. By the mid-1950s, however, vertical coordination of these activities through contracts and vertical integration had become increasingly common.

Broilers³

Production contracts, whereby the contractor and grower (or a smaller producer) each provide significant inputs into the production process, have been the dominant means of coordinating broiler production since the mid-1950s (fig. 2).⁴ Initially, feed companies contracted with broiler growers, spurred by a potentially large and stable market for their feed. As broiler production grew in the South, production contracts evolved to give the contractor more control over production and shift more price and production risk from growers to contractors.

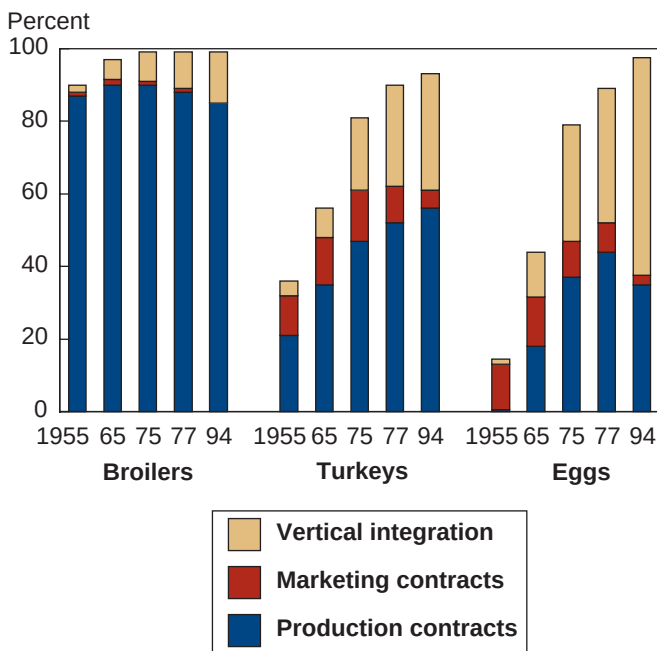
In the 1960s, feed-company contractors became involved in broiler processing by acquiring or constructing processing plants. Contractors, such as

³See Martinez (1999) for more details regarding developments in broiler contracting and vertical integration.

⁴Continuous time series data sets that document methods of vertical coordination are generally not available. National surveys and individual State studies provide some indications of these developments at particular points in time.

Figure 2

Poultry and eggs produced under contracts and vertical integration



Note: According to Roy (1963), independent broiler production accounted for 95 percent of total production in 1950.
Sources: Rogers (1979); Manchester.

Ralston-Purina, Allied Mills, Central Soya, Cargill, and ConAgra, controlled broiler production capacity from feed mills to processing and marketing.

In the early 1970s, broiler price swings caused many feed companies to reduce their investments in the poultry business (Strausberg). Processors, such as Tyson Foods and Hudson Foods, then took over the role of contractor. Today, nearly all broiler production and processing is coordinated through production contracts between growers and processors. Contract terms typically specify that the processors will provide the baby chicks, feed, and management and veterinary services. The growers provide the labor and chicken houses and receive a payment per pound of live broilers produced, based on a grower's performance relative to other growers.

Turkeys

Before 1950, turkey growers operated independently, obtaining financing from traditional sources (local banks, production credit associations) to pay for feed, poult, and supplies (Roy, 1972). However, in the 1950s, the industry experienced financial setbacks, and these traditional sources became more reluctant to

finance turkey growing. Consequently, hatcheries provided poult financing, and feed companies provided both feed and poult financing as a means to expand feed production. These financial arrangements eventually evolved into production contracts that shifted risk from grower to contractor.⁵ By 1961, feed companies accounted for 65 percent of total turkey production under contract (Gallimore). To coordinate production and processing, many feed companies also owned hatcheries and acquired processing facilities. As the turkey industry developed throughout the 1960s, processors became increasingly involved in turkey production decisions (Manchester). Processors began raising their own turkeys or contracting to better schedule production and ensure supplies.⁶ By 1977, as fewer outlets existed for independent growers, the share of turkeys sold on the U.S. spot market fell to only 10 percent of turkeys produced.

Today, production contracts account for about 56 percent of turkey production and vertical integration accounts for about 32 percent. Production contracts in the turkey industry are similar to resource-providing production contracts in the broiler industry: the grower provides the buildings, equipment, and labor, and the processor provides poult, feed, veterinary services, and managerial assistance. Most growers receive a fee per bird or per pound that may include performance incentives for feed conversion and reduced turkey mortality rates (Lasley, Henson, and Jones). Vertically integrated operations, in which the processor owns all production facilities and hires labor to care for the birds, are more prevalent in the turkey industry than in the broiler industry.

Eggs

In the egg industry, significant increases in contracting by feed companies and processors began in the late 1950s. As in the broiler industry, contracts in the egg industry evolved to give the contractor more control over production and reduce growers' price and production risks. Grower returns became less dependent on market prices, as flat-fee payments (for example, per bird, per dozen eggs) or payments related to produc-

⁵Similar to the broiler industry, turkey production contracts evolved from financing arrangements, in which the contractor sometimes participated in the management decisions, to risk-sharing arrangements (Gallimore and Vertrees).

⁶According to Gallimore and Irvin, unlike the broiler industry, processors, rather than feed companies, were "the major coordinators in the turkey industry."

tion efficiency became more common (Rogers, Conlogue, and Irvin). Today, production contracts account for more than a third of eggs produced. In a typical production-contract arrangement, the contractor provides layers, feed, and other supplies, and the grower provides labor and facilities. All eggs produced under the contract belong to the contractor, and the grower is paid a fee based on the number of eggs produced, with performance incentives.

In the mid-1970s, large owner-integrated operations in the egg industry expanded rapidly. Most vertically integrated operations resulted from forward integration by producers into processing (Rogers, 1976). Integrators produce, pack, and market eggs in their own facilities and may also mix feed, operate hatcheries, and raise pullets (Rogers, 1979). Compared with vertical integration in the broiler and turkey industries, vertical integration in the egg industry is more commonly used to coordinate production and processing and accounts for 60 percent of eggs currently produced.⁷

Vertical Coordination in the Pork Industry

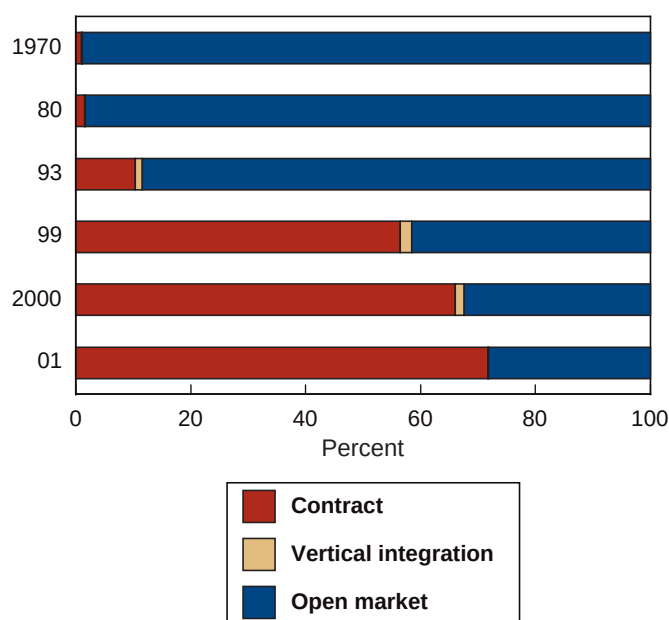
Since the early 1990s, the pork industry has experienced significant changes in vertical coordination (fig. 3). Marketing contracts between large producers and processors have become increasingly common. Contract terms typically specify that the producer will deliver a certain quantity of hogs to the processor at a certain time. The producer may receive a formula-based price, typically a spot-market price (for example, the Iowa/Southern Minnesota market quote), with premiums or discounts based on size and quality of the hogs.

Production contracts also are becoming more common in the pork industry (fig. 4). Under the terms of these contracts, the contractor, typically a large producer or processor, provides management services, feeder pigs, veterinary services, and other inputs. The grower provides land, facilities, and labor to feed the hogs to

⁷As in the turkey industry, cooperatives were an important force in the egg industry, performing such functions as assembling, packing, and distribution (Rogers, 1971; 1976). Cooperatives used marketing contracts with producer-members to address quality control and secure egg supplies. As production contracts and larger vertically integrated operations became more dominant in the industry, marketing contracts declined. Today, marketing contracts account for less than 3 percent of eggs produced.

Figure 3

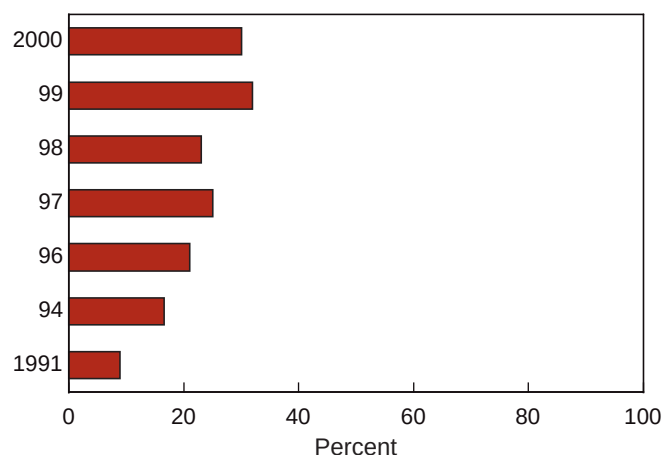
Share of hogs delivered to processors via contracts and vertical integration



Sources: Hayenga et al., 1996; Marion; University of Missouri and National Pork Producers Council; and Kelley.

Figure 4

Share of hogs produced through production contracts



Note: Shares for 1996 through 2000 are as of December 1 each year. Sources: Plain and USDA[a].

market weight.⁸ The grower receives a fixed payment, with premiums for efficient production. As in the poultry industry, processors in the pork industry may own feeder pigs and establish production contracts with

⁸ While finishing contracts are the most common arrangement, production contracts may also be used for nursing or farrowing.

growers to feed the hogs to market weight. Packer-owned hogs increased from 6.4 percent of U.S. hog production in 1994 to 24 percent in 2000, reflecting Smithfield Foods' (the Nation's largest hog producer and processor) recent purchases of two leading hog producers (Messenger, April 2000). Most of these hogs are priced using formula-based marketing contracts with the production unit (Grimes and Meyer).⁹

⁹Grimes and Meyer categorize these contracts as formula-based marketing contracts. In our classification scheme, these contracts are best described as production contracts because the processor owns significant production inputs.

Hog producers and processors may enter into both production and marketing contracts. For example, Prestage Farms, the Nation's fourth-largest hog producer, produces its hogs under production contracts with growers. Prestage then sells the hogs to Smithfield Foods, using marketing contracts at market-indexed prices.

Incentives for Contracting and Vertical Integration: A Transaction Cost Approach

To explain alternative forms of vertical coordination in the poultry, egg, and pork industries, one must rely on the existence of market failures (Milgrom and Roberts). In the traditional neoclassical paradigm, coordination through spot markets can reconcile the individual objectives of many consumers, direct many valuable and limited resources to production, and motivate firms to produce the right products. The resulting allocation of goods is efficient given the following assumptions:

- Each producer knows prices and production technology and maximizes profits.
- Consumers know prices and preferences and maximize utility given income.
- Prices adjust to equate supply and demand for each good.

Under these assumptions, prices allocate resources to their most valued use, and consumers prefer no other allocations given available resources and technology. In reality, however, firms have concerns about their ability to buy and sell the quantities they want at given prices. Buyers and sellers may not know the exact specifications of goods that they demand or supply. Buyers face costs associated with searching for adequate suppliers offering the most favorable prices, and sellers face costs associated with communicating the availability of products with specific attributes.

This report applies the transaction cost economics (TCE) paradigm, which relies on the existence of transaction costs.¹⁰ Transaction costs are costs associated with reaching and enforcing agreements and have been equated to “the costs of running the economic system” (Masten, 1996; Williamson, 1996). Transaction costs include those costs associated with planning, adapting, and monitoring economic activities. While these functions are not directly productive,

¹⁰Other explanations for alternative methods of vertical coordination include (i) to increase profits in noncompetitive markets (Royer), (ii) to price discriminate and create barriers to entry (Stigler), (iii) to shift price and production risk to firms that can manage risk more efficiently (Knoeber and Thurman; Martin, 1997), (iv) to ensure input supplies (Carlton), and (v) to sustain a strategic competitive advantage (Westgren).

they are required to coordinate the activities of buyers and sellers.

TCE analysis suggests that the main purpose and effect of contracts and vertical integration is to reduce transaction costs. Transaction costs associated with spot-market coordination include buyer costs of searching for suppliers offering preferred quality features at favorable prices and seller costs of determining prices and buyer preferences. Buyers and sellers can reduce some of these costs by entering into a contract arrangement before production is completed, but they can still encounter other types of costs. *Ex ante* (prior to reaching an agreement) contracting costs are costs associated with drafting, negotiating, and safeguarding agreements. *Ex post* (following an agreement) costs are costs associated with enforcing agreements and may require measuring damages or injury to a contract party, enacting penalties, and compensating an injured party (North). Vertical integration may reduce costs of contracting and spot-market trading but may also introduce new types of transaction costs, including costs related to communicating information within a firm (Putterman and Kroszner). Firms choose a method of vertical coordination based on a comparison of the net effect on transaction costs.

Asset Specificity

Transaction costs and the choice of vertical coordination method depend on characteristics of the transaction. The TCE paradigm places an emphasis on the degree of *asset specificity* in an exchange relationship, or the degree to which assets are specifically designed or located for a particular use or user. Once specific assets are locked into a relationship, they can be redeployed only at a great loss in productive value, which results in sizable quasi-rents.¹¹ Because relationship-specific assets have much lower value in other uses by other users, they reduce the number of potential trading partners. Hence, the investing party will be subject to *holdup*, or exploitative, self-interested actions (also referred to as opportunistic behavior) by the other party to appropriate the quasi-rents and generate above-normal returns.

A decline in the number of buyers and sellers also can lead to *small-number* bargaining problems (Frank and Henderson). Coupled with specialized assets, small-

¹¹The difference between the value of an asset in its best use and in its next-best use is referred to as “quasi-rent.”

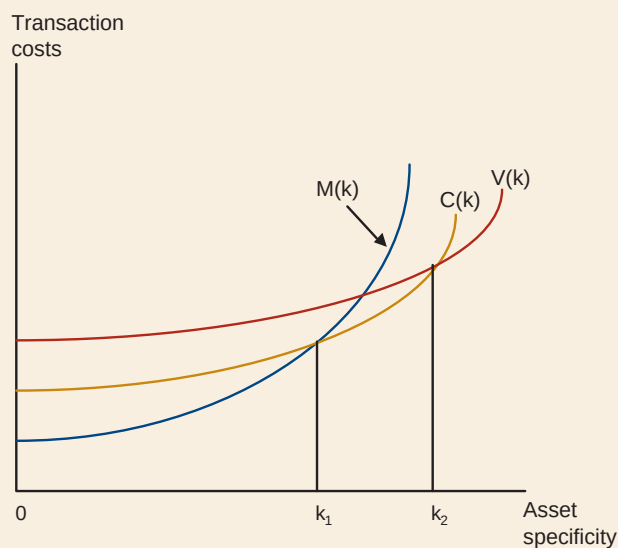
number bargaining increases the potential for opportunistic behavior because alternative exchanges cannot be easily arranged. Asset specificity and small-number conditions, however, create value in enduring exchange relationships.

Types of asset specificity include physical, site, and temporal. Physical specificity is derived from the physical features of an asset. For example, special-purpose equipment and specialized investments required for scale economies are physical specificities (Williamson, 1979). The buyer of the finished product can appropriate quasi-rents that are generated from these investments by offering a price lower than the originally agreed-upon price. As long as the offer price exceeds the value of the asset in its next-best use, the producer has few options but to accept the offer. Site specificity occurs when buyers and sellers locate facilities close to each other to reduce transportation costs. Because relocation costs are high, site specificities lock parties into an exchange relationship for the useful life of the asset. For example, a producer may be deciding whether to locate a farm operation close to a processor. The quasi-rents generated are the difference between the negotiated price and the price available from the next-closest processor, less transportation costs. Once again, the buyer can appropriate these rents by offering a lower price than originally agreed. Temporal specificity refers to the timing of delivery and its effect on product value. For example, temporal specificities may arise because a producer of a perishable product has

difficulties finding alternative processors on short notice. The buyer may appropriate the quasi-rents by threatening to delay acceptance of the product. Temporal specificities are less severe in “thick” markets where large numbers of buyers and sellers enhance competition (Pirrong).

A party that invests in specific assets will choose alternatives to spot-market coordination that provide safeguards against opportunistic behavior and reduce resource expenditures on haggling and bargaining over price. In a contract relationship, one party may agree on investments to be made and quantities to be delivered. The other party may agree on prices to pay based on various contingencies that arise over time. Private actions for breach of contract and public laws protecting contract parties help enforce contracts and protect contract parties. As assets become more specialized, the investing party will expend more resources to specify more contract contingencies because there are greater benefits from “holding up” the asset owner. In addition, parties may not always honor contracts, and these actions may result in costs associated with investigating contract violations and court litigation. Consequently, vertical integration, which eliminates the exchange relationship, becomes more prevalent as asset specificity and the potential benefits to reneging on contracts increase (Klein, Crawford, and Alchian) (see box on relationship between asset specificity, transaction costs, and methods of vertical coordination).

Relationship between asset specificity, transaction costs, and methods of vertical coordination



Source: Williamson, 1991.

Methods of vertical coordination are chosen to minimize transaction costs. In the figure, k is the level of asset specificity, $M(k)$ is transaction costs associated with spot-market coordination, $C(k)$ is costs associated with contracting, and $V(k)$ is costs associated with vertical integration. Each method of vertical coordination is expressed as a function of asset specificity. For low levels of asset specificity ($k < k_1$), transaction costs of spot-market coordination are minimal. As asset specificity increases to intermediate levels ($k_1 < k < k_2$), contract arrangements minimize transaction costs. For transactions characterized by high levels of asset specificity ($k > k_2$), vertical integration becomes the cost-minimizing method of vertical coordination.

Uncertainty

In addition to varying by asset specificity, transactions may vary by degree of uncertainty, which arises from three basic sources (Williamson, 1996; 1985; Koopmans). First, uncertainties arise due to technological changes, unpredictable changes in consumer preferences, and random acts of nature. Second, uncertainties may arise from lack of timely communication or the inability to determine simultaneous decisions and plans made by others, such as investment decisions and purchasing plans of consumers. Third, uncertainties may arise due to strategic behavior regarding nondisclosure, disguise, or distortions of information (also referred to as “behavioral uncertainty”).

Greater uncertainty, coupled with asset specificity, increases the importance of organizing relationship-specific transactions in ways that avoid costly haggling by adapting to market conditions. Bounded rationality, which makes it impossible, or very costly, to specify all possible contingencies or appropriate adaptations in advance, makes it necessary for parties to adapt or “work things out” (Williamson, 1985).¹² That is, bounded rationality makes it costly to write a complete contract. Therefore, contracting parties are susceptible to opportunistic behavior as contracts are renegotiated in response to changing market conditions. Monitoring of performance and verification of breach of contract also become more difficult as uncertainty increases. In cases where the degree of asset specificity is low, uncertainty is expected to have no effect on vertical coordination because little value is placed in an ongoing relationship. The need to adapt to market conditions is lessened because alternative exchanges can be quickly arranged in light of unexpected events.

Given investments in specific assets, parties may respond to increasing uncertainty in two ways. First, parties may engage in contracts that may become more relational in nature. That is, instead of laying out specific details, contracts will specify the process through which future terms of trade will be determined. Contract terms will be specified that provide incentives for rent-increasing adaptations to changing market conditions, while limiting opportunism and the need for costly arbitration (Masten, 1996). For example, instead of negotiating a specific contract price, parties

may agree to adjust the contract price based on a market-determined index. This arrangement reduces incentives to gain advantage by obtaining special information on future prices. In addition, if a negotiated contract price differs substantially from the market price, the disadvantaged party may be reluctant to continue the agreement. The party may then engage in subtle, costly behavior, such as requiring strict adherence to the rules, purposefully delaying deliveries, or interpreting the contract literally.¹³ Market-based contract prices, which narrow the gap between contract price and market price, reduce these types of inefficient behavior.

Contracting parties may also respond to increasing uncertainty by progressing from marketing contracts to vertical integration in the spectrum of control (fig. 1) (Frank and Henderson). When the level of uncertainty becomes particularly high, *ceteris paribus*, vertical integration is expected to become more prevalent.¹⁴ While contracting relies on the ability to anticipate potential problems, vertical integration requires no contract revisions and serves to facilitate adaptation to changing circumstances as they unfold (Masten, 1996). Vertically integrated firms can more readily adapt to changing conditions because opportunistic behavior is less likely within such a firm, disputes can be settled by top management, convergent expectations can facilitate planning, and access to relevant information can reduce haggling (Dietrich).

Measurement Costs

Transaction costs can also result from information asymmetry among trading partners regarding product value and producer effort. Some important attributes of a traded good may not be directly observable to the buyer, seller, or both. Consequently, parties may benefit by engaging in costly searching and sorting to obtain information about the attribute of the good. For example, a producer may sell low- and high-quality products at the same price, and the purchaser may expend resources to search for undervalued goods and reject those that are overpriced. Contracts that include compensation for efficient producer performance may require parties to measure appropriate indicators of production efficiency. Social waste occurs when mea-

¹²Bounded rationality refers to limits on people’s knowledge, foresight, skill, time, and ability to articulate knowledge in a way that can be understood by others.

¹³According to Goldberg and Erickson, literal interpretation is often referred to as “working to the rules.”

¹⁴The term “*ceteris paribus*” is used in economics to indicate that all variables except those specified are assumed not to change.

surement by buyers to determine the true value of a good simply redistributes wealth from sellers to buyers (Leffler, Rucker, and Munn). Expanding time and effort in haggling and delaying agreements to influence the terms of exchange is also inefficient (Milgrom and Roberts).

Vertical coordination arrangements can reduce transaction costs related to inefficient measuring and sorting, and leave more gains from exchange to be distributed among contracting parties. If measuring output quality were cost free, spot-market production would provide

effective price incentives for performance. On the other hand, if measuring output quality were costly, parties would be encouraged to shirk, cheat, and engage in other types of opportunistic behavior. To limit such behavior, markets may be reorganized so that accurate measurements require less effort and cost (Milgrom and Roberts). For example, in contracts in which output is difficult to measure and inputs serve as an adequate proxy for output value, buyers may enter into contract arrangements that enable them to monitor production inputs.

The Viability of Spot-Market Transactions in the Poultry, Egg, and Pork Industries

This report examines the role of contracting or vertical integration in reducing transaction costs in the poultry, egg, and pork industries and relates transaction characteristics to vertical coordination methods over periods of significant change in vertical coordination. Asset specificity and measurement costs are examined as possible sources of transaction costs that reduce the efficiency of spot-market trading.¹⁵

Physical Specificities and Small-Number Conditions

Firms that specialize in certain types of output or differentiated products, or those with highly technical production processes, may require investments in specialized assets.¹⁶ Investments in assets that have few alternative uses, coupled with fewer outlets or input suppliers, determine the relationship-specific nature of the transaction. In the broiler, turkey, egg, and hog markets, investments in relationship-specific assets suggest a role for contracts and vertical integration, particularly in geographic regions undergoing industry expansion.

Broilers and turkeys

Following World War II, the poultry industry experienced rapid changes in technology, which induced more specialized production facilities, processing plants, and breeding stock designed for the production of chickens for meat or for eggs. In the broiler industry, most growers invested heavily in chicken housing. As noted by Breimyer, "As a broiler house cannot be converted readily to uses other than poultry, the financial obligation imposes a tight restraint on a grower's freedom of action." Similarly, the U.S. Department of

Agriculture, Packers and Stockyards Administration found that "limited alternative uses for existing investments in broiler enterprises and limited off-farm employment, principally in the South, have kept many farmers in broiler production in spite of excess capacity and generally low returns."

Investments in specialized broiler production and processing assets affected the relationship-specific nature of transactions by limiting alternative uses and users of such investments. While broiler houses may be specific in a production sense (that is, specialized to broiler production), they may not represent relationship-specific investments unless there also are few buyers.¹⁷ Scale economies associated with specialized technology adoption resulted in fewer and larger firms, especially in expanding regions of the South.¹⁸ According to Reimund, Martin, and Moore, technological innovations could be adapted more readily in areas with relatively little output because existing capital investments and production methods had less influence in these areas.

The extent of technology adoption and associated scale economies in the South is indicated by changes in the size and number of U.S. broiler firms as the share of production in the South increased (fig. 5) (app. B). In 1964, 201 processing firms operated 320 plants that slaughtered 6.7 billion pounds of broilers. By 1984, 134 firms operated 238 plants that slaughtered 17.8 billion pounds. Larger plants became more prevalent in the South as broiler slaughter capacity became more concentrated in this region. In 1984, pounds slaughtered per plant in the South averaged 99 million pounds, compared with the U.S. average of 73 million pounds. On the production side, from 1959 to 1982, the number of farms selling broilers fell from 42,185 to 30,100. Over the same period, the share of U.S. broiler sales by large broiler farms (100,000 or more birds) increased from 29 to 89 percent (Lasley et al.).

Similarly, in the turkey industry, investments in specialized assets had a significant effect, especially in the South. As confinement and semi-confinement production operations replaced range rearing, increasingly specialized production stages created demand for

¹⁵Efficiency of alternative organizational arrangements is typically related to observable characteristics of the transaction because transaction costs are difficult to measure directly (Joskow). Hence, transaction-cost economics requires detailed information on organizational form and attributes of transactions (Williamson and Masten).

¹⁶Proxies for physical asset specificity used in the empirical literature include fixed assets to shipments, fixed assets to number of employees, advertising (representing intangible assets, such as brand name and reputation) to shipments, expenditures on research, ratio of research and development expenditures to sales, and the difference between acquisition price and salvage value (Mahoney; Frank and Henderson; MacDonald; Shelanski and Klein; Sporleder; Caves and Bradburd).

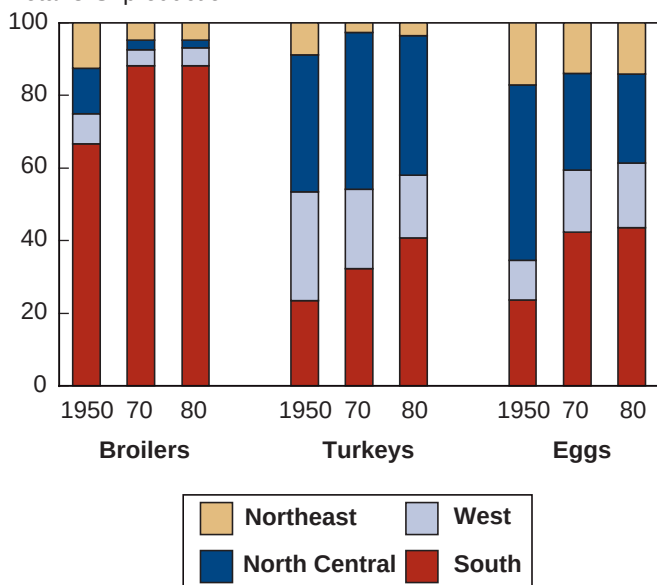
¹⁷I thank Jill Hobbs for emphasizing this point.

¹⁸In addition to the relationship-specific nature of these investments, larger operations are associated with larger quasi-rents and, hence, greater benefits from holdup by the other party (Pirrong).

Figure 5

Geographic patterns of poultry and egg production

Total U.S. production



Source: Lasley.

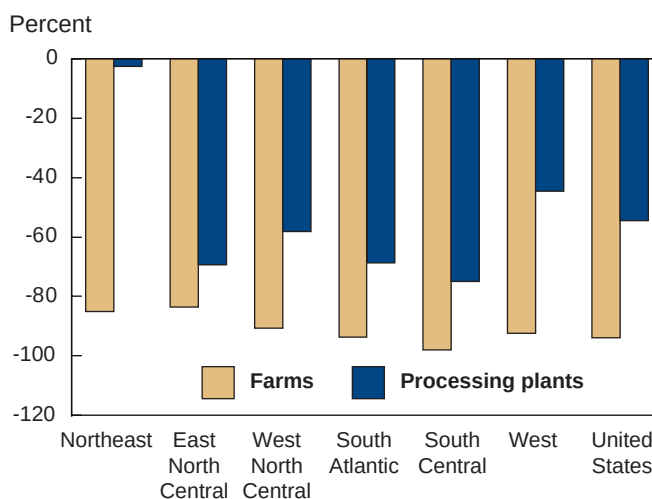
feeds, equipment, and other products and services designed for each stage (Rogers, 1979; Small). By the mid-1980s, large and specialized turkey processing plants replaced plants that slaughtered both broilers and turkeys during the broiler slack season, a common practice in the 1960s (Gallimore and Irvin; Lasley, Henson, and Jones). Regional variations in the adoption of new, specialized production technology were reflected by the rapid decline in number and growth in size of turkey production and processing operations (figs. 6, 7, and 8).

Table eggs

In the table egg industry, specialized production replaced the general farm flock due to improvements in breeding, feeding, disease control, management, and marketing. For example, as in the broiler industry, pullet growing in the table egg industry was dominated by specialized, large-scale operations using mass-production techniques (Roy, 1972). Technological innovations in the 1950s and 1960s, including automated egg washers, blood spot detectors, and automated egg cartoners, encouraged large-scale production and mechanized handling and distribution of a large number of

Figure 6

Decrease in number of turkey farms (1959-78) and processing plants (1962-81)

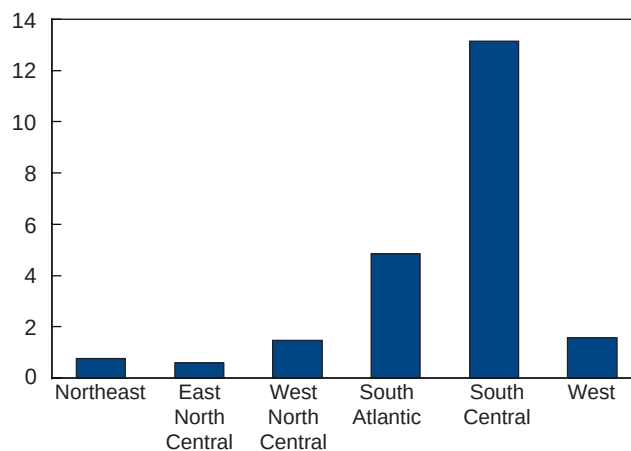


Source: Lasley, Henson, and Jones.

Figure 7

Increase in average number of turkeys per farm, 1959-78

Percent (thousands)



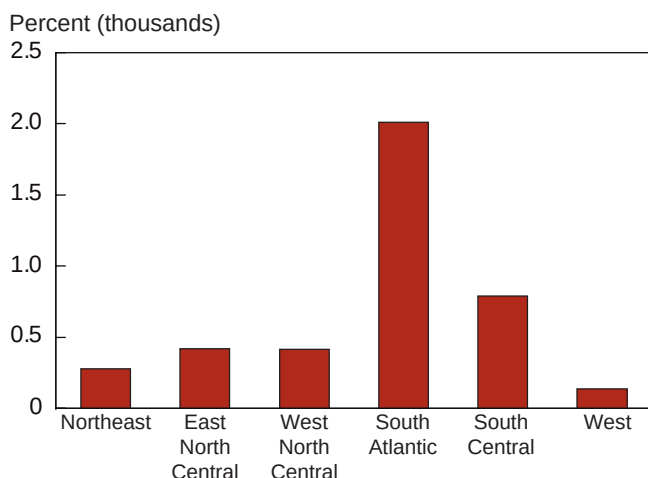
Source: Lasley, Henson, and Jones.

eggs.¹⁹ Large-scale enterprises could implement new, highly mechanized technology more advantageously than smaller operations, which encouraged further

¹⁹Modern "in-line" operations that mechanically gather, clean, grade, and package the eggs require large capital investments for environmentally controlled housing and computer technology to control egg flow, quality control, and packaging. Typically, eggs on commercial egg-laying farms are never touched until they are handled by the food service operator or consumer (United Egg Producers).

Figure 8

Increase in average number of turkeys per plant, 1962-81



Source: Lasley, Henson, and Jones.

growth in specialized egg production units (National Commission on Food Marketing; Strausberg).

Regional changes in the size and number of egg operations reflect corresponding differences in the rate of specialized technology adoption. Emerging table egg production areas of the South and West experienced significant increases in the size of flocks (fig. 9).

While the number of farms selling eggs fell 72 percent from 1959 to 1978, the rate of decline was highest in States where total output expanded (Lasley; Rogers, Conlogue, and Irvin). Average egg-packing volume also was above average in plants in the South and in areas of the West and below average in the North Central, where plants were less efficient (Rogers, Conlogue, and Irvin).

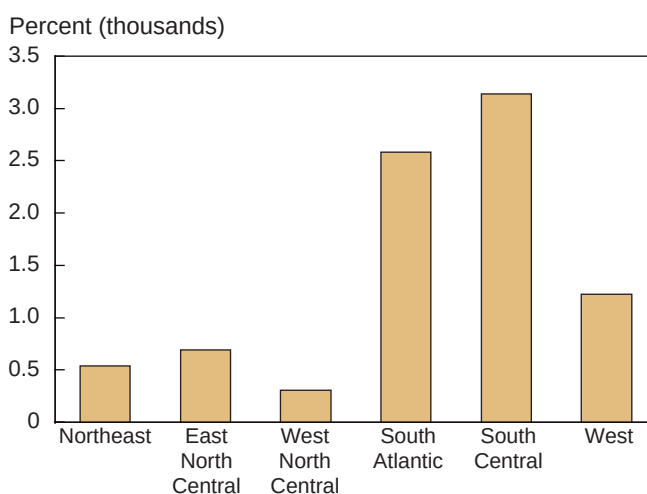
Hogs

The pork industry has been moving toward more specialized hog production and processing operations for over 60 years, but the trend appeared to accelerate in the 1990s (Hurt). Modern facilities are equipped with state-of-the-art technology dedicated only to pork production (Brewer, Kliebenstein, and Hayenga). These new technologies are more commonly used in the larger hog-production operations (see box on hog production technologies).

Expanding hog-production regions (for example, the South Atlantic region, led by North Carolina, and the

Figure 9

Increase in average number of eggs sold per farm, 1954-68



Source: Rogers, Conlogue, and Irvin.

South Central region, led by Oklahoma) used the newer, specialized technologies nearly a decade before the traditional hog-production areas of the North Central region (Brewer, Kliebenstein and Hayenga; Hurt; Hurt, Boehlje, and Hale) (fig. 10). The North Central region, which had its last major capitalization in the late 1970s and early 1980s, was characterized by smaller, more diversified farming operations and older hog-production technology (Foster, Hurt, and Hale). Much of the newer technologies could not be fully implemented by these operations given their existing physical and human capital.

Regional differences in the adoption of the newer technologies, and associated scale economies, are reflected by differences in the size of operations. In 1997, units marketing 7,500 or more hogs and pigs accounted for nearly all production in North Carolina and Oklahoma, compared with less than 40 percent of production in Iowa and Illinois (Martinez, 2000). Lower production costs for large operations resulted from the application of specialized technology, large capital expenditures, bulk purchasing, and other strategies to achieve economies of scale (Brewer, Kliebenstein, and Hayenga).

Small-number conditions also were apparent in regions of hog-industry expansion. A limited number of processors accounted for a large share of slaughter capacity in the expanding-production regions, South Atlantic and South Central, compared with the North

Large-Scale Hog Production Technologies

Since the 1980s, and especially since 1989, U.S. hog production has been shifting to highly specialized, large-scale farms. Large-scale hog production technology differs from small-scale production technology in several ways. Newer buildings, three-site production, and the use of all-in/all-out and isoweaning, split-sex/phase feeding, and artificial insemination typically characterize large-scale operations.

In the 1970s and 1980s, farrow-to-finish operations with fewer than 1,000 hogs and pigs were the most common method of producing hogs. In these small-scale operations, hogs are raised from birth to market. In larger scale, commercial hog operations, specialization occurs in the three phases of production: farrowing, nursing, and finishing. Many hogs are produced on three sites (that is, one for each phase of production) while having one owner. The facilities at each site may be owned by the owner of the hogs or by another producer who raises the hogs under a production contract. From 1978 to 1995, farrow-to-finish operations fell from 78 percent of all U.S. hog farms to 35 percent.

Disease transmission throughout the various production stages, which reduces growth rates, lean tissue deposition, and feed conversion efficiency, is more difficult to control in larger operations. Mixing groups or ages of hogs compromises the animals' health because pathogens can enter through breeding stock, feeder pigs, and other sources. Larger operations use high tech methods, such as all-in/all-out production and isoweaning, to prevent the spread of disease. With all-in/all-out production, all animals are replaced at the same time, and buildings are cleaned and disinfected before another group of animals arrives. With isoweaning, weaning piglets (that is, young pigs separating from the sow) are placed in isolated accommodations to eliminate infectious agents. Precautionary measures ensure that each group of isoweaned pigs is not contaminated by pigs of other ages. In traditional farrow-to-finish operations, younger pigs are placed in direct contact with older pigs.

Because nutrient requirements vary as pigs age, and male and female pigs develop differently after reaching a certain weight, different levels of nutrients are required in a pig's diet to optimize lean growth. To obtain the most efficient feed conversion, market hogs may be separated by sex by the time they reach 70 pounds and fed different diets (split-sex feeding). Changing a hog's diet several times in a hog's life also improves feed efficiency (phase feeding). Splitting the tube that distributes feed to the hogs and using additional feeding equipment (for example, feed bins and sort boxes) enables hogs to be fed different diets at different locations in the building. Furthermore, the types of feeds flowing through the feed distribution tubes can be switched. While many smaller operations use these techniques, they are more commonly used in large operations.

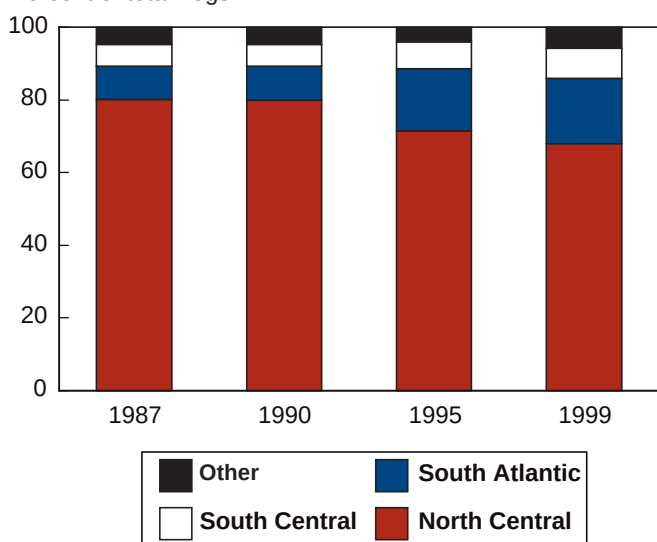
Attempts to improve leanness and other traits in hogs require changes in the hogs' genetic makeup. With artificial insemination (AI), the genetic makeup of hogs can be quickly controlled and changed, and new genetics can be easily sampled. An AI program also can be tailored to the needs and goals of each farm. The use of artificial insemination increased from less than 1 percent of U.S. sows in the early 1990s to approximately 40 percent in 1998.

Sources: Brewer, Kliebenstein, and Hayenga; Marbery; Cline et al.; Singleton and Schinckel; Harris and Harris; Hayenga et al.; Schrader; Hodson; Martinez, Smith, and Zering.

Figure 10

Share of hog inventory accounted for by regions

Percent of total hogs



Note: Inventories as of December 1.

Source: Compiled by ERS/USDA from USDA[a].

Central region (fig. 11). This scenario leaves producers with fewer alternative outlets and, hence, makes them more vulnerable to opportunistic behavior by existing processors. The number of alternative hog suppliers to

packing plants also was especially limited in the expanding regions (fig. 12).²⁰ Traditionally, hog-packing plants were concentrated in the North Central region because of the abundant supply of hogs within a reasonable distance of the region's packing plants (Zering, 1995). More packing capacity generated more hog production, which generated more packing capacity, and so on. In 1992, this pattern of regional concentration growth was broken when Smithfield Foods opened the world's largest pork-packing plant in Tar Heel, North Carolina.²¹ Smithfield's plant was twice as large as any plant in the North Central region (Hurt, Boehlje, and Hale). The plant also was built to Japanese and European standards, featuring optical probes to measure backfat and loin eye depth and magnetic resonance imaging to measure fat content in hams (Miller, May 2000). The opening of this facility occurred at a time when the North Carolina/Virginia region already had excess processing capacity, a limited share of U.S. hog inventory, and few other hogs and processors within reasonable trucking distance.

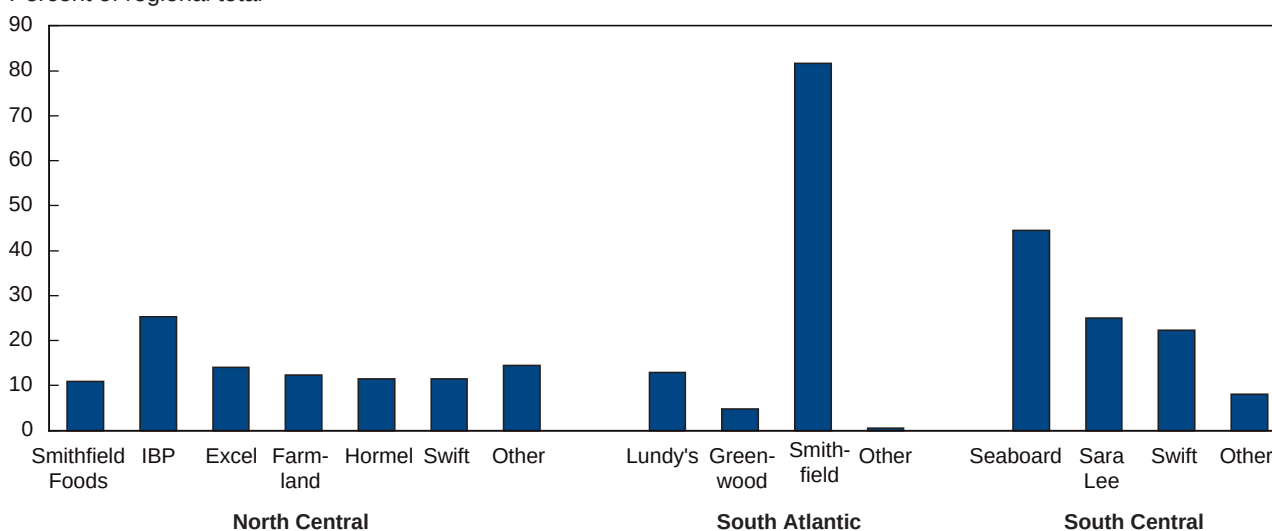
²⁰From 1981 to 2000, the number of U.S. hog farms fell from 579,000 to 86,000 (USDA[a]).

²¹Later, in 1995, Seaboard opened a large state-of-the-art processing plant in Guymon, Oklahoma.

Figure 11

Hog-packing capacity by firm and region, 1999

Percent of regional total

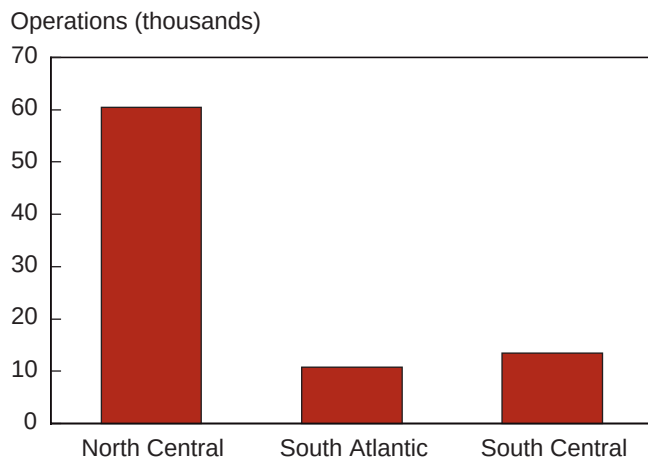


Note: Excel is a subsidiary of Cargill, and Swift is a subsidiary of ConAgra.

Source: Compiled by ERS/USDA from *Pork Facts*, National Pork Producers Council, 2000.

Figure 12

Number of U.S. hog and pig operations, December 1, 1999



Source: Compiled by ERS/USDA from USDA[a].

Changing methods of vertical coordination in regions of industry expansion²²

In light of investments made in new specialized assets and small-number conditions in expanding poultry, egg, and hog markets, transaction-cost considerations suggest that the spot market was an inefficient means of vertical coordination in regions of industry expansion. At the same time, contracting in the broiler and turkey industries became more prevalent in the South. Similarly, table egg contracting increased in the South as well (table 1). In the late 1950s, egg production contracts existed mostly in the Southern States, where contracting and large-scale flocks were common because of the region's sizeable broiler industry. By the mid-1960s, egg production contracts had spread to the West, where contract systems and large, vertically integrated egg complexes that require huge investments developed together.

In the pork industry, expanding production in nontraditional regions also was accompanied by marketing contracts and packer-owned hogs produced under production contracts. A 1994 survey of large hog producers found that large producers in the North Central region marketed 26 percent of hogs through the spot market and 63 percent using marketing contracts. In

²²In this section, information on regional differences in methods of vertical coordination is obtained from Roy (1963; 1972); Gallimore; Rogers, Conlogue, and Irvin.; Rogers (1979); and Lawrence et al.

Table 1—Table egg production and contracting in the South

State	Change in production, 1959-65	Production under contract, 1964
	Percent	
Alabama	71	45
Georgia	72	33
Arkansas	159	50

Source: Gallimore and Vertrees.

areas outside the North Central region, the difference was greater; 14 percent of hogs were sold through spot markets, and 81 percent were sold through marketing contracts. For example, Smithfield Foods, which has most of its slaughter plant capacity in the South Atlantic region, obtains 50 percent of its slaughter requirements from company-owned hogs, and an additional 14 percent are obtained from marketing contracts (Smithfield Foods, 10K, filed July 28, 2000). Seaboard Farms has most of its slaughter capacity in the South Central region and owns about 75 percent of the hogs that it slaughters (Marbery). On the other hand, in 1999, IBP, which has slaughter plants in the North Central region and is the Nation's second-largest pork processor, did not own sows (Freese). The company's main supply of hogs is purchased daily by IBP buyers, a few days before processing (IBP, 10K, filed March 23, 2000).²³

Investments in specialized genetics for producing pork with unique quality attributes also have increased. For example, in the early 1990s, Smithfield Foods introduced Lean Generation Pork in response to diet and health concerns related to fat content of foods. Lean Generation Pork is produced from National Pig Development (NPD) hogs, the leanest hogs in U.S. large-scale production. In this case, specialized genetics represents a relationship-specific asset, regardless of small-number conditions, because it is tied to a specific brand. Smithfield obtained uniform genetics for the pork through a partnership with a leading hog producer, Carroll Foods, involving long-term marketing agreements and joint ownership of hog-production operations.

²³In each of the next 5 years, IBP is committed to purchasing about 21 percent of its annual hog production capacity, using marketing contracts with payments based on market-derived prices (IBP, 8-K, filed November 7, 2000).

Site and Temporal Specificities²⁴

Limited procurement distances also created relationship-specific transactions in the poultry and egg industries. Parties can move chickens only about 30 miles and still remain profitable because live birds lose weight if transported over lengthy distances.

Consequently, as advances in distribution technology made it more efficient to transport processed poultry products, site specificities were created when large processing plants moved closer to the flocks.

Production density was more critical than optimal processing plant size in determining the competitive position of processors. As processors sought high-production density to reduce the span of their broiler supply sources, many contract growers had essentially no alternative trading partners. Vertically integrated operations, in which the integrator owns both the production and processing facilities, were more common with larger-than-average broiler houses located closer to the processing plants.

Timing factors create temporal specificities in the poultry, egg, and pork markets.²⁵ Poultry and eggs are considered to be perishable products. Poultry requires a withdrawal period, whereby growers withdraw feed before the birds are processed to limit intestinal contents and protect against fecal contamination of poultry carcasses. Processing delays can result in deterioration of the birds' intestines, which increases susceptibility to rupture and contamination. Furthermore, the pressure required to remove the crop in older birds can rupture the crop, spill its contents, and lead to salmonella contamination, which suggests that poultry must be sent to the processor within a narrow age range.²⁶ In addition, large investments by poultry processing plants in the late 1950s, in response to mandatory inspection requirements, increased the importance of timely bird supplies. Table eggs undergo weight loss and albumen deterioration immediately after lay, so eggs must reach the supermarkets within a few days of leaving the laying house to ensure a fresh and safe product.

²⁴This section is based on information contained in Henry, Chappell, and Seagraves; Rogers (1976); Marion and Arthur; Roy (1972); *Pork '99* Staff; Byrd; Martinez (1999); Van Leusen and Ceton; and United Egg Producers.

²⁵Rapid structural changes in the production of poultry, eggs, and pork that resulted in thin markets, particularly in regions of industry expansion, may have increased the severity of temporal specificities.

²⁶The crop stores undigested feed and is removed at processing.

In the pork industry, timely delivery of hogs to the processing plant affects processing costs. Modern pork processing plants are designed to operate efficiently at a particular utilization level, and operating costs rise rapidly at other levels of production.

Measurement Costs

While consumers gain by understanding the value of a good, measuring the good at the point of sale may be costly to the consumer. Some meat attributes, such as taste and product safety, are costly to verify before the meat is consumed. In addition, consumers incur a cost sorting through heterogeneous packages of equal price to affect the distribution of gains but do not alter the overall quality of the products. As household leisure time becomes more valuable, such sorting becomes even more costly.

Many product attributes that can influence consumers' eating experiences depend on the characteristics of animals supplied for processing. These characteristics may be difficult to measure when the animals are sold, but production inputs, such as genetics, feed and nutrition, and management practices, may affect certain product attributes. For example, the pale, soft, exudative (PSE) condition in hogs, which is associated with tough, dry, and lean pork, is difficult to measure when hogs are sold but is highly heritable (K.E. Smith). Measuring pathogen content also may be difficult. Furthermore, it is costly to measure and sort animals of varying size, shapes, and quality within and across flocks and herds.

Contracts and vertical integration, together with branding of retail meat products, can reduce total measurement costs within the food system. Branded products tend to reduce consumer concerns about purchasing a deficient product. Such a product could tarnish the brand name and saddle the producer with potentially critical losses. For this reason, the quality of branded products is expected to be less variable. Quality assurances inherent in branded products are especially important for those product attributes that are difficult for the consumer to measure at the point of purchase. Instead of consumers incurring the cost of attribute measurement at the time of purchase, processors can measure product characteristics more cheaply further upstream, or earlier in the process.²⁷ For those quality

²⁷"Upstream" refers to stages of the marketing system closest to the beginning of the production process. "Downstream" refers to those stages closest to the consumer. Value is added as product moves downstream through successive stages to consumers.

attributes of a live animal or carcass that are costly to measure, processors can reduce measurement costs by controlling farm inputs through contracts or vertical integration.²⁸ Substituting measurement by consumers with earlier, less costly measurement further upstream reduces total measurement costs in the food system, leaving more gains to be distributed among buyers and sellers.²⁹ As sellers bear some of the cost of buyer pre-sale measurement, sellers would also benefit (Barzel).

Branding has been an integral part of the poultry industry for over 20 years. For example, Tyson Foods, the Nation's leading broiler producer, maintains a strong national brand. Tyson's broiler contracts specify that growers use only company-supplied birds, which come from genetic stock supplied by Tyson's breeding stock company, Cobb-Vantress. Tyson invests in breeding stock research and development to produce birds with the most desirable natural characteristics. In the turkey industry, Jennie-O Foods, the world's leading turkey processor, emphasizes branded, packaged consumer items, such as the company's rotisserie turkey. The company owns turkey production facilities and supplements output from these operations with grower

²⁸Furthermore, tournament production contracts used in the broiler industry also reduce measurement costs by basing grower payments on a grower's performance relative to other growers (a tournament). This feature reduces measurement costs because relative performance is cheaper to measure than absolute performance associated with weight and other factors, such as feed efficiency and mortality rates (Knoeber).

²⁹The opposite is true for consumer warranties. According to Barzel, warranty contracts on finished products, such as household appliances and other durables, reduce measuring costs because it is cheaper for consumers to determine output quality as the product is used than for manufacturers to test every product.

contracts that specify the breed to be used, in addition to weight and pricing formula (Hormel Foods, 10-K, January 23, 1998).

Leading egg companies also emphasize branding. Cal-Maine Foods, the Nation's largest egg company, produces branded egg products for health-conscious consumers under the Egg-Land's Best and Farmhouse labels. Egg-Land's Best eggs (with "EB" stamped on each egg) come from hens that are fed all-natural, vegetarian diets, with no animal by-products, and contain less saturated fats than regular eggs. Farmhouse eggs are produced from free-range hens that feed on natural grains. Attributes of these branded products, which depend on special feeds and production practices, would be difficult to measure by consumers and processors in a spot market.

As in the poultry industry, contracts and vertical integration in the pork industry may lower measurement costs and facilitate branding programs for fresh pork (chops, tenderloins, ribs, and roasts). Companies that have recently introduced branded fresh pork products include Hormel Foods and Seaboard. Hormel obtains 50 percent of its hog supplies from 5- to 10-year marketing contracts (Egerstrom). These contracts specify that producers use Hormel-approved facilities and genetics that can produce lean, uniform-sorted hogs. Seaboard controls genetics and nutrition for its Prairie Fresh label through integrated, environmentally controlled operations. The Pig Improvement Co. provides the genetic base for producing uniform products with fewer PSE-related meat attributes, resulting in less moisture loss and juicier meat after cooking (Marbery, June 5, 2000).

Marketing Contracts, Production Contracts, or Vertical Integration?

While characteristics of poultry, egg, and pork market transactions and associated transaction costs suggest that spot-market trading will be inefficient, the significance of alternative vertical coordination arrangements varies across industries. Vertical integration of the production and processing stages is more prevalent in the turkey and egg industries, while marketing contracts are more common in the pork industry. Reasons for these differences are explored in the following section.

Uncertainty and Vertical Acquisitions

In markets with significant asset specificity, increasing levels of uncertainty are expected to lead to methods of coordination that transfer more control over functions to the integrator. During periods of extensive changes in structure and vertical coordination in the poultry and egg industries, uncertainty originated from a variety of sources.³⁰ Disease and heavy mortality rates were found among birds (Black). Significant technological advances were made within a short period of time (technological uncertainty) (Tobin and Arthur; Martinez, 1999).³¹ Poor coordination of sales between producers and buyers led to wide market swings. Sharp industry losses in 1959 and 1961, characterized by overproduction and depressed live-bird

prices, led many hatching-egg producers, hatcheries, and feed companies to exit the broiler and turkey industries. Extensive changes in competitive conditions, mergers, and acquisitions at all stages in the 1960s (National Commission on Food Marketing) and rapid inflation fueled by OPEC (Organization of the Petroleum Exporting Countries) in the early 1970s created further uncertainties.

In the late 1950s and early 1960s, uncertainty in the broiler industry led management centers to become involved in stages further downstream in the vertical chain (Tobin and Arthur). At the time, rapidly increasing broiler sales complicated coordination of vertical stages. Advances in technology at all stages led to excess production and depressed prices. Greater demand for research and new product development increased demand for capital through periods of erratic price movement. Retailers who offered chicken breasts and thighs at one price and drumsticks at another complicated inventory control (Strausberg). Lack of communication with buyers of dressed broilers and overemphasis on broiler shortages and surplus led to the demise of open markets further upstream. Feed companies began to deal directly with wholesalers or retailers by acquiring or merging with processors and by building their own processing facilities. Consequently, production-related decisionmaking was enhanced by the retailers' superior knowledge of consumer preferences and buying habits.

In the pork industry, sources of uncertainty include government regulations (for example, environmental regulations, family farm ordinances) and hog prices (table 2). In recent years, hog prices have become more sensitive to changes in hog production (fig. 13). Hog demand has become more inelastic, which has led

³⁰Proxies for technological uncertainty in the empirical literature include years to technological obsolescence, frequency of changes in product specification, and probability of technological improvements (Mahoney).

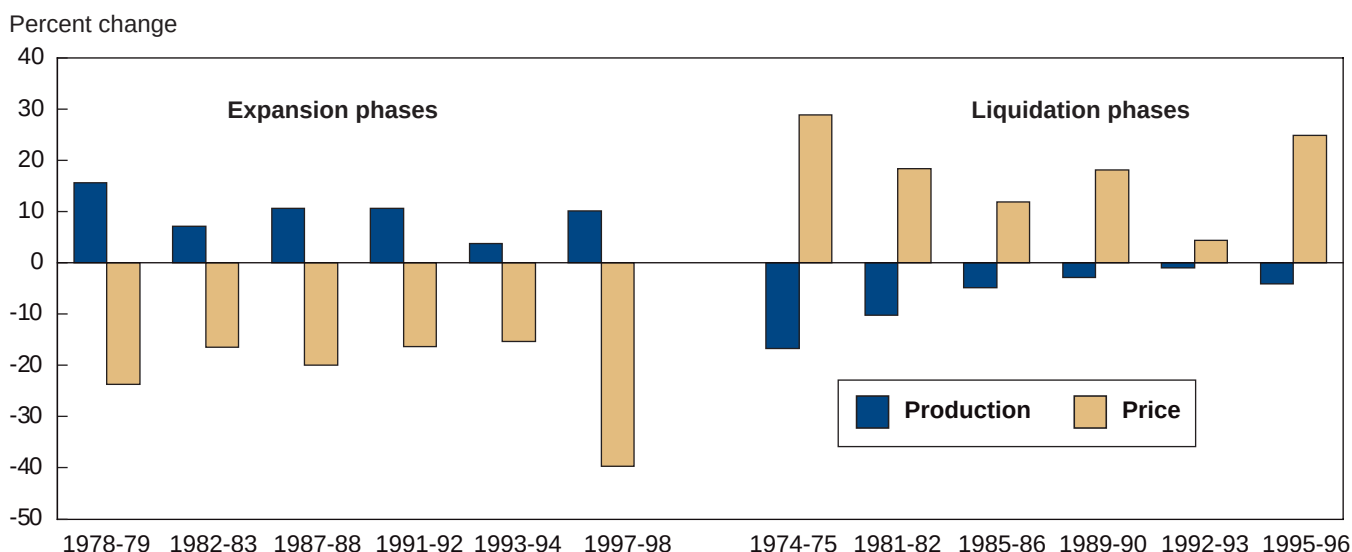
³¹In the United States, shell egg production accounts for over 70 percent of total table egg production.

Table 2—Types of uncertainty faced by selected pork companies

Firm	Type
Hormel	Hog prices and availability, government regulations, consumer acceptance of products, and interest rate debt.
Smithfield Foods	Availability and prices of live hogs and raw materials, product pricing, competitive environment and market conditions, and failure or inability to comply with government regulations, including environmental and health regulations.
Seaboard Farms	Hog and raw material prices, third-party hogs, and pork prices.
Farmland Industries	Federal, State, and local environmental laws and regulations, disease, genetic changes, market prices for hogs, strength of competition, and regulatory delays that affect growth strategies, joint ventures, and operational alliances. Note: Includes uncertainty that may cause a company's actual results to differ substantially from forward-looking statements.

Sources: Smithfield Foods, Form 10Q, March 14, 2000; Hormel, Form 10-K405, January 28, 2000; Farmland Industries, Form 10-Q, January 14, 2000 and Form S-1, January 19, 2000; and Seaboard Farms, Form 10-Q, April 28, 2000. Filings with the Securities and Exchange Commission.

Figure 13

Hog price and production changes over selected periods

Source: Compiled by ERS/USDA from Meyer.

to more volatile prices and revenues. The demand elasticity for a factor of production will be smaller in absolute value as its share of total production cost becomes smaller (Thurman). Hence, an increase in the proportion of pork that is consumed in further-processed form is expected to result in a smaller (in absolute value) own-price demand elasticity. As pork is bundled with other goods and services, the percentage of the pork price accounted for by marketing services increased 14 percentage points between 1990 and 2000, from 55 to 69 percent, compared with only a 5-percentage point increase from 1980 to 1990.

Another source of uncertainty in the pork industry is the competitive environment in which firms operate. Processors compete in an environment in which strategy and pricing by one company can dramatically affect the competitive outcome of another firm, which also has consequences for the company's suppliers (Di Pietre).

As in the poultry industry in the 1960s, vertical acquisitions and coordination of production and processing through production contracts, led by Smithfield Foods, has become more common in the pork industry. Following 50-year lows in hog prices in fall 1998, Smithfield purchased two leading hog producers with which it had marketing contracts. In 2000, Premium Standard Farms (PSF), the 2nd-largest hog producer and 13th-largest hog slaughter firm, acquired Lundy

Packing, a hog slaughter firm based in North Carolina, which more than doubled PSF's processing capacity.

Vertical Integration in the Turkey and Egg Industries

While uncertainty in the poultry, egg, and pork markets has been associated with increases in production contracts and vertical integration, vertical integration is much more prevalent in the turkey and egg industries. One possible contributing factor to the prevalence of vertical integration is that uncertainty is more significant in the turkey and egg industries. In turkey production, both disease susceptibility and longer growing periods increase uncertainty (National Commission on Food Marketing; Gallimore; Strausberg; Roy, 1972). With longer growing periods, more time elapses between a change in buyers' plans and corresponding changes in production, so it takes longer to react to price changes resulting from demand shocks. Consequently, efficient transfer of information between parties becomes more important, which, ceteris paribus, increases the likelihood of vertical integration (Caves and Bradburd). Turkeys are marketed at 4-7 months of age, compared with 5-6 weeks for broilers, so adjustments in broiler production can be made more quickly. The table egg production cycle is also longer than the broiler cycle (Strausberg).

Income uncertainty from shell egg sales may be especially significant to vertical integration.³² Differences in procurement methods of two of the top three U.S. egg producers support this statement. Cal-Maine Foods produces 78 percent of its eggs in vertically integrated facilities, in which feed is manufactured, chicks are hatched, pullets are grown, and eggs are produced, packed, and distributed (Cal-Maine Foods, Form 10-K, filed with Securities and Exchange Commission August 21, 2000). Cal-Maine procures the remaining eggs through production contracts with growers who own their own egg-production facilities. On the other hand, Michael Foods procures only 35-40 percent of its eggs from company-owned hens and purchases the remainder through marketing contracts and the open market (Michael Foods, Form 10-K, filed with Securities and Exchange Commission March 31, 1999). Cal-Maine sells nearly all of its eggs in the shell egg form, whereas Michael Foods sells 94 percent as further-processed eggs, such as reduced-cholesterol products, liquid eggs, and precooked omelets. Greater uncertainty in shell egg sales makes vertical integration by Cal-Maine a more efficient means of coordination. Income from shell egg sales is sensitive to the highly variable market-based wholesale price of shell eggs (Urner Barry Price Quotation).³³ The production of value-added products can help limit uncertainty related to price changes in commodity shell eggs. Gross margins from sales of value-added egg products are generally less sensitive to commodity price fluctuations.³⁴

Changing consumer tastes and preferences for table eggs provided an important source of demand uncertainty. Beginning in the 1950s, faster paced lifestyles led consumers to favor lighter breakfasts and less fresh egg consumption. In the 1970s and 1980s, health concerns raised by nutritional studies linking cholesterol and fat to heart disease contributed further to the downward trend in egg consumption (Brown and Schrader).

³² In the United States, shell egg production accounts for over 70 percent of total table egg production.

³³ Variance of prices makes it easier for firms to cheat by raising their price (Klein, Crawford, and Alchian). Evidence from the petrochemical industry suggests that input price uncertainty in the 1970s led to more vertical integration into input stages (Fan).

³⁴ Michael Foods recently sold shell egg production facilities to reduce exposure to the commodity egg market and to focus on production of value-added products (Smith, 2000).

The inefficiency of tournament contracts, commonly used in broiler production, could also contribute to more vertical integration in the turkey and egg industries. In tournament contracts, grower payments adjust automatically to production influences common to all growers because payments are based on *relative* performance of growers, which is not affected (Knoeber). Hence, these contracts do not require costly renegotiation of contract terms in response to shared production influences, such as rapid advances in production technology. However, tournaments require a large number of contestants (growers) to effectively reduce risk-bearing costs.³⁵ Tournament contracts perform more efficiently in the broiler industry than in the turkey and egg industries because there are more broiler growers relative to processors (Knoeber). The design of tournament contracts for turkey and egg production was less feasible.

Transaction costs associated with significant site specificities in the egg industry also suggest that vertical integration is a more efficient means of organizing transactions than other methods of vertical coordination. Technological breakthroughs in the 1960s led to high-speed, in-line grading, in which eggs are conveyed directly from laying cages to grading and packing machines. Soon after 1961, on-farm egg processing became the norm (Jasper). These packing and processing operations may be considered an extreme form of site specificity because they are located at the same site as the farms.

Temporal specificities in markets associated with shell egg production also may be significant to vertical integration. For example, Cal-Maine produces mostly shell eggs, which are highly perishable as indicated by the company's low shell egg inventory, consisting of 4 days of production (Cal-Maine Foods, Form 10-K, filed with Securities and Exchange Commission August 21, 2000). On the other hand, Michael Foods produces mostly egg products. Furthermore, over periods of important changes in vertical coordination, reductions in the number of alternative egg producers with which to bargain were more severe than in the broiler indus-

³⁵ In the transaction cost economics literature, the risk-shifting role of coordinating methods is ignored. This has been justified based on several factors, including (i) the ability of owners to diversify their business to limit the effects of risk, (ii) the inability to directly observe risk preferences, and (iii) the lack of attention to other explanations for business arrangements by focusing on risk aversion (Masten, 1996).

try. From 1959 to 1978, the number of egg farms fell 72 percent, compared with an 18-percent reduction in the number of broiler farms over the same period (Lasley). This finding suggests that thin markets increased the severity of temporal specificities.³⁶

Less dense production areas in the egg industry, compared with the poultry and pork industries, suggest that vertical integration may be especially prevalent in egg markets. Geographically concentrated regions may provide a check on opportunism associated with specific assets, which suggests that motives for vertical integration would be more pronounced in geographically dispersed industries, as firms vertically integrate to protect against opportunism. The egg industry is more widely dispersed than the poultry and pork industries (app. C). News of opportunistic behavior also may spread more rapidly in concentrated regions, which would reduce the likelihood of holdup and lessen the need for vertical integration (Enright). For example, in the pre-1960s U.S. tuna industry, small boats and frequent deliveries to port served to constrain processor opportunism because of the potential for losing the trust of current and potential trading partners (Masten, 1996). That is, the high density of trading partners that could observe and communicate instances of opportunism put the processors' reputation at stake.

Marketing Contracts in the Pork Industry

While processor-owned hogs are becoming more common in the pork industry, marketing contracts remain the prevalent method of vertical coordination in the pork industry, particularly in comparison with the poultry and egg industries. The prevalence of asset specificities in the poultry and egg industries possibly leads to more vertical integration, which reduces the likelihood of holdup. In hog markets, temporal specificities have less influence on vertical coordination because there is greater flexibility in the age at which hogs can be slaughtered (*Pork*' 99 Staff). Site specificities also have less influence because hogs have a higher dressing percentage and more value, which enables them to be transported longer distances (*Pork*' 99 Staff).

Greater uncertainty, coupled with investments in relationship-specific assets, typically results in fewer marketing contracts and greater reliance on production

contracts and vertical integration. However, marketing contracts that are relational in nature provide a compelling incentive for reliance on these contracts in the pork industry. With formula-priced contracts, which are the most popular type of hog marketing contract, payments adjust automatically to changes in market conditions because contract payments are typically linked to a spot-market price.³⁷ This feature limits opportunities for producer or processor holdup because it is not necessary for parties to continually renegotiate the base price.³⁸ In addition, following significant changes in vertical coordination in the poultry and egg industries, advances in information technology may have reduced some sources of uncertainty for the pork industry in the 1990s. These advances would lessen the need for production contracts and vertical integration, which offer more control to the contractor and integrator.³⁹

Another factor that may influence the pork industry's reliance on marketing contracts is that processors contract with fewer and larger hog producers using a uniform set of inputs. By establishing marketing contracts with large hog producers, coordination occurs across fewer firms, which can substitute, albeit imperfectly, for greater control offered to processors through production contracts and vertical integration. Marketing contracts also may give the processor some control over hog quality and uniformity by stipulating inputs to be used by the producer. A survey of 19 of the largest hog processors found that half of the packers with marketing contracts required a minimum volume to be supplied, and either the minimum quality of hog to be supplied or their genetics (Hayenga et al., 1996).

³⁷ These contracts provide no shifting of price risk because the contract price varies directly with the spot-market price.

³⁸ Spot-market prices are often adjusted based on quality premiums and discounts, which may provide an area of contention. However, changes in private grading programs occur less often than changes in spot prices.

³⁹ In their empirical analyses using transaction cost economics, Levy and Frank and Henderson construct a measure of unanticipated demand uncertainty. Their analysis is accomplished by calculating the variance of the residuals from a regression of logged food industry, or firm, sales on a time trend. Similarly, in this report, annual logged pork, broiler, turkey, and egg expenditures were regressed on a time trend to construct a measure of demand uncertainty. Poultry and egg uncertainty was calculated over two periods of extensive changes in vertical coordination, 1955-64 and 1965-74. To compare, recent demand uncertainty in the pork industry was calculated for the period 1990-99. Statistically, the variance of residuals for poultry and eggs was significantly larger in the 1965-74 period than the variance for pork. However, in the 1955-64 period, only broiler demand uncertainty exceeded recent pork uncertainty.

³⁶ The decline in the number of turkey farms also was quite severe, falling 92 percent from 1959 to 1978.

Processors that contract for large numbers of hogs from uniform supplies have stopped measuring every hog, basing payments instead on periodic samples and the distribution of quality (Di Pietre). In 1999, Smithfield Foods had marketing contracts with 3 of the top 10 hog producers (Murphy Farms, Maxwell Foods (also known as Goldsboro Hog Farm), and Prestage Farms), accounting for 29 percent of slaughter. These producers, in turn, established production contracts with growers, which provided substantial control over

production. After acquiring two large hog producers, Murphy Farms and Carroll Foods, Smithfield currently has production contracts with 1,200 growers, representing about 70 percent of hog production in North Carolina (Marbery, December 18, 2000). On the other hand, Tyson Foods has contracts with 7,402 broiler growers (Tyson Foods).

Beyond Transaction Costs: Benefit Effects From Contracting and Vertical Integration

While contracts and vertical integration can minimize transaction costs, these arrangements also may facilitate new, more efficient resource allocations (Dietrich; Milgrom and Roberts; Klein, Crawford, and Alchian; Demsetz; Langlois). “Benefit effects” resulting from more efficient resource allocations increase, rather than merely redistribute, gains from exchange. For example, if a firm overcomes supplier quality deficiencies, benefits extend to production, by price and/or productivity changes. In the poultry, egg, and pork industries, benefit effects from resource allocations include improved production efficiency and changing product characteristics that lower costs and increase demand.

Production Efficiency Gains

Lower production and processing costs associated with changes in vertical coordination can be derived from a number of sources. First, contracting or vertical integration can induce firms to make optimal investments in relationship-specific assets. The threat of opportunism in the spot market may discourage parties from investing in highly productive specific assets (for example, genetics, modern in-line egg facilities and equipment). Without contracts or vertical integration to safeguard against opportunism, the producer and processor each may invest in more flexible, less efficient technology that could be used for a wider range of customers.⁴⁰ On the other hand, investments in more specific assets and increased management control may alter the production function to increase pro-

ductivity at higher volumes. Second, contract arrangements and vertical integration also may encourage buyers and sellers to locate closer to each other, thereby lowering transportation costs. Other potential sources of cost savings include improved scheduling of perishable product deliveries and faster responses to changing market conditions.

Important technological innovations in poultry and egg production resulted in significant gains in production efficiency, as measured by feed requirements, length of production period, and output per bird (table 3). Efficiency gains, over periods of extensive changes in vertical coordination, were passed on to consumers in the form of large supplies of lower priced meat and egg supplies (fig. 14). The broiler industry was the last of the poultry and egg industries to develop, as technological innovations helped to fuel rapid growth of the industry (Martinez, 1999). Commercial broiler production was practically nonexistent in 1930, and until 1948, most of the chickens sold were old, tough, egg-type chickens that were primarily by-products of the egg industry. Production of chickens bred for meat rather than egg laying increased from 100 million pounds in 1934, when the numbers were first compiled, to 3 billion pounds in 1953. Another 20-year period, 1960-80, saw broiler production nearly triple, compared with only a 35-percent increase in nonbroiler chicken production. Over the same period, less sizeable, but substantial increases in the turkey industry occurred as production doubled, and despite falling demand for table eggs, egg production rose by 13 percent.

Studies have verified that broiler contracting had lower production costs than independent broiler production and influenced the industry’s growth and efficiency (Roy, 1963, 1972; Marion and Arthur; Tobin and Arthur). Important sources of cost reductions in the broiler industry from 1955 to 1962 included economies of scale at all stages, closer proximity of birds to pro-

⁴⁰According to Masten (1998), the effects of contract protection on the willingness of transactors to make beneficial relationship-specific investments are just beginning to be analyzed.

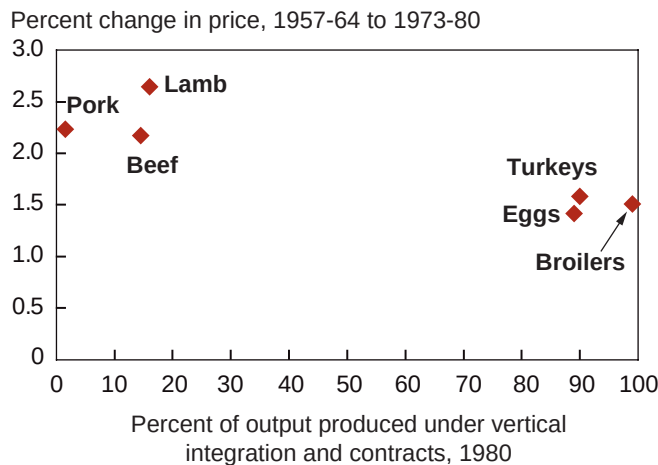
Table 3—Efficiency gains in the poultry and egg sectors

Year	Broilers			Turkeys			Eggs	
	Age to market (wks)	Feed per pound of gain (lbs)	Market weight (lbs)	Age to market (wks)	Feed per pound of gain (lbs)	Market weight (lbs)	Eggs per hen per year	Feed per dozen eggs (lbs)
1925	15.0	4.0	2.8	34	5.5	13.0	112	8.0
1950	12.0	3.3	3.1	24	4.5	18.6	174	5.8
1975	7.5	2.1	3.8	19	3.1	18.4	232	4.2
1990	6.5	1.9	4.5	16	2.6	21.1	250	4.0

Source: University of Arkansas.

Figure 14

Relationship between retail prices and share of U.S. output under closely coordinated production



Source: Compiled by ERS/USDA from Lasley; Marion.

cessing plants, and closer forms of vertical coordination. Increases in broiler contracting in the South provided the impetus for the region's expanding production, while other regions had lower levels of contracting and lagged in production volume. Low production costs made it feasible for processors to ship broilers to all parts of the United States and overseas as well.

The turkey industry also benefited from cost reductions (Roy, 1963, 1972; Gallimore and Irvin). A highly coordinated turkey production and marketing system in the South, along with mild weather and low transportation rates, helped enable the region to overcome disadvantages in feed costs. In the 1960s and 1970s, vertically integrated firms usually had better management control and lower costs.

In the 1960s, close proximity of large table egg flocks to egg-packing plants lowered procurement costs and increased the optimal size of the packing plants, resulted in sizable scale economies (Rogers, Conlogue, and Irvin). Without the industry's arrangements to protect against opportunism, however, eggs obtained from small and dispersed flocks would limit plant size. That is, it would be infeasible for processors to expand the procurement area to support a larger specialized plant. At a particular distance, procurement costs would exceed gains from scale economies. The cost of eggs from vertically integrated table egg firms is significantly lower and less variable than the cost of eggs from spatially separate production units associated

with spot-markets and contract operations (George Morris Centre Food Industry Research Center; Roy, 1963; Michael Foods, Form 10-K, filed with Securities and Exchange Commission March 31, 1999).

More recently, contracting in the pork industry has been associated with continuing gains in production efficiency. Larger litter size, more litters per sow, and heavier market weights have resulted in 30 percent more pork per breeding animal in 1999 than in 1990. In 1999, a 4-percent smaller breeding herd than in 1998 produced 7 percent more pork. Larger hog operations that produce hogs under contractual arrangements tend to have higher production efficiency and lower costs (Kliebenstein and Lawrence; USDA, Animal and Plant Health Inspection Service). In areas of expanding production, productivity gains of hog production have helped to offset feed cost advantages enjoyed by the Midwest.

Quality and Uniformity

The broiler industry has successfully adapted breeds and processed products to meet consumer preferences. Consumer preferences are shaped by a number of factors, including demographics (for example, workforce composition, household size, ethnic diversity) and information linking diet and health.⁴¹ Consequently, consumers increasingly demand a wide variety of branded products that can be prepared quickly or consumed away from home (Kinsey). The TV dinner was the first major prepared poultry product to win consumer acceptance and provided considerable benefits to working mothers of the 1950s and 1960s (Strausberg). As broiler integrators became increasingly dissatisfied with low, highly variable prices for "commodity" chickens, they focused on the development of value-added chicken products (Strausberg).⁴² In the 1980s, branded fresh chicken and further-processed products became increasingly popular with consumers. For example, Tyson Foods introduced a rolled tortilla with a chicken-based filling for the Nation's rapidly growing Hispanic market. By 1990, the company expanded its product line to include pre-cooked fried chicken.

⁴¹According to marketing specialists, value influences market share, where value is defined as perceived benefits from consumption divided by price (Ritchie et al.).

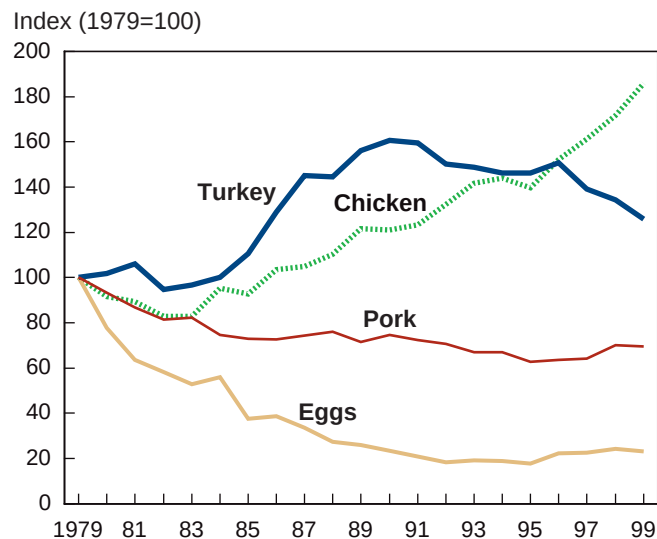
⁴²The deflated price of chicken paid by retailers fell 25 percent from 1974 to 1980.

How do contracts and vertical integration facilitate response to changing consumer demands? As value-added food processing increases and specifications for the raw materials become more stringent, material inspection must become more rigorous as well. In the spot market, prohibitive testing costs and sampling and measuring errors can cause underinvestments in farm-level quality control (Hennessy). The situation is especially relevant when processors place a significant premium on quality and consistency of inputs (see box on marinating and breeding of chicken products) or when quality is difficult to identify in the raw product, as with food safety. Under these circumstances, there are incentives for processors to substitute costly measuring with vertical integration or production contracts. Hence, contracts and vertical integration could facilitate resource allocations that improve the quality and uniformity of chicken supplies by removing the need to test for quality (Hennessy). At the same time, transaction costs associated with measuring product attributes are reduced.

The benefits of further-processed, branded products are suggested by increases in broiler demand, as measured by the broiler demand index, corresponding to expanded value-added products in the 1980s (fig. 15). Demand indices represent percentage changes in

Figure 15

Poultry, egg, and pork demand relative to 1979



Source: Compiled by ERS/USDA.

demand relative to 1979. Each index is calculated by comparing actual changes in per capita broiler consumption to changes that result from variations in the retail chicken price (app. D). A broiler index approximating 200 in 1999 suggests that broiler demand nearly doubled since 1979.

Marinating and Breeding of Chicken Products

Automation enables poultry processors to quickly and efficiently meet the high-volume demands of foodservice outlets and supermarkets for further-processed, branded products. As demonstrated by the processes in which chicken is marinated and breaded, those demands place a premium on uniform size and shape of poultry. Most marinated products, which are the fastest growing and highest volume value-added products, are injected with marinade on the processing line. A tray loader automatically accumulates and deposits cut-up chickens on a conveyor belt. While workers are required to spread and turn the cut-up chicken for injecting with marinade, no manual sorting is required.

In the early 1980s, most processors began to manufacture breaded products (most of which are first marinated) in response to the popularity of breaded chicken in the fast food industry. The development of in-line bread and batter machines enabled the production of breaded chicken on a commercial scale. A conveyor belt pulls cut-up chicken parts through a bed of breading to cover the underside of the chicken parts. Breading is also sifted from above to cover the tops of the chicken parts. Modifications to the machines include rollers, flips (to turn the product over), and blowers (to remove excess breading). The amount of breading material applied to the parts depends on a number of factors, including size and shape of the raw products.

Fast food companies, such as Kentucky Fried Chicken, prefer broilers that are small and uniform for portion and cost control purposes. Breaded chicken parts of uniform weight and size facilitate even frying.

Sources: Benton; Smith (October 1999); Marion and Arthur; Horowitz and Miller.

Because the demand index provides no information on the cause of the demand shift (price of competing meats, income, tastes, and preferences), a regression equation is used to explain per capita chicken consumption. A simple linear demand equation is estimated using data from 1970 to 1982:

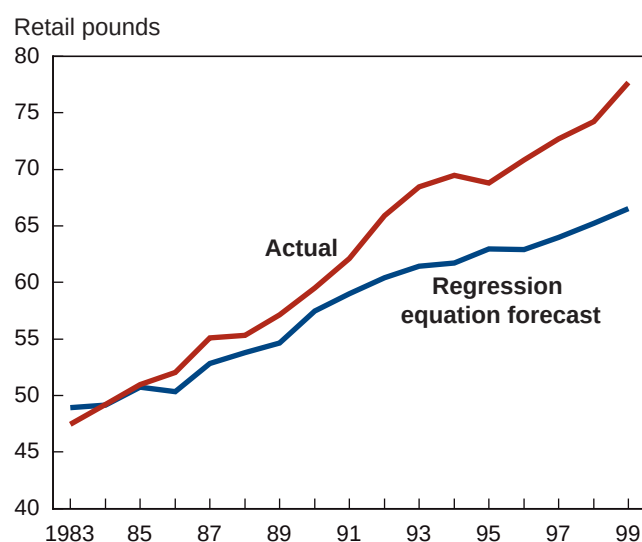
$$\text{PCC} = 32.8 - .18 \times \text{CHICKEN} + .05 \times \text{BEEF} + 1.5 \times \text{INCOME}, R^2 = .96,$$

where PCC is per capita consumption, CHICKEN is the retail price of chicken, BEEF is the retail price of beef (chicken substitute), and INCOME is per capita disposable income. Forecasts of per capita chicken consumption are obtained by substituting actual values of the independent variables, from 1983 to 1999, into the regression equation. These forecasts are consistently below actual per capita consumption, which suggests that factors other than prices and income have accounted for persistent increases in per capita consumption after 1982 (fig. 16). The industry's response to changing consumer tastes and preferences, along with consumer perceptions regarding the healthfulness of chicken versus red meat, has apparently influenced the growth in broiler demand.

In the turkey industry, increased production of cut-up and further-processed turkeys led to tighter control over input specifications to provide more uniform

Figure 16

Actual versus forecasted per capita broiler consumption



Source: Compiled by ERS/USDA.

birds of specific weight (Rogers, 1979).⁴³ Demand for the turkey roll (one of the first processed items) and other processed products developed slowly, as consumers were slow to change their eating habits. However, 90 percent of turkeys are now processed beyond the ready-to-cook form, compared with 17 percent in 1963 and 33 percent in 1970 (Gallimore and Irvin; Gardner and Hyatt). Consequently, the availability of value-added products has extended turkey consumption from Thanksgiving and Christmas to other times of the year (fig. 17).⁴⁴

Growth in table egg contracting and vertical integration was influenced by mass merchandisers' demand for egg quality and uniformity. A growing demand for higher quality eggs by egg-breaking plants reflected efforts by food manufacturers to improve the quality of their products (Roy, 1963). Modern, vertically integrated facilities produce a high percentage of grade A eggs, which sell at higher prices (Cal-Maine Foods, Form 10-K, filed with Securities and Exchange Commission August 21, 2000).⁴⁵

In the pork industry, contracts and vertical integration can facilitate production of case-ready products by reducing measuring costs and protecting against opportunistic behavior associated with specialized investments in genetics. Case-ready pork is packaged, priced, and labeled by the processor for store display. Uniformity in size and weight of hogs is required for size control in the production of standardized case-ready products.

⁴³ In the early 1960s, some smaller firms had well-known brand names and indicated a preference for expanding through buying or leasing farms, instead of contracting, because integration could help maintain quality associated with these brand names (Gallimore).

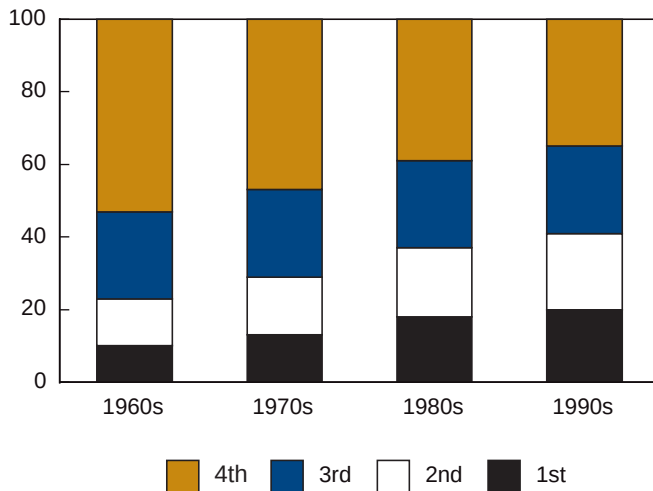
⁴⁴ Evidence suggests that an increase in turkey demand in the mid-1980s (fig. 15) was likely due to new product development and consumer preferences for white meat (Cheney et al.).

⁴⁵ While egg demand has fallen since the 1950s because of convenience and health-related factors (Brown and Schrader), more recent developments have apparently stabilized the decline in egg demand (fig. 15). In the 1990s, per capita egg consumption increased 9 percent, compared with a 13-percent decline in the 1980s, as the percentage sold in egg-product form continued to increase. For example, more liquid egg products are now sold at grocery stores as a cholesterol-free and safer alternative to shell eggs. In addition, recent research indicates that the correlation between egg consumption and cholesterol levels is not as strong as once thought.

Figure 17

Per capita turkey consumption by quarter

Percent of total consumption



Source: ERS, USDA.

Allocating resources to the production of case-ready meat offers several benefits. Case-ready meat promotes the development and expansion of branded products (M. Miller) and reduces retailer labor costs related to meat handling and cutting. Case-ready pork also facilitates reductions in the frequency of “out-of-stocks,” which refers to products that are sought by consumers but are not on the display shelves (Messenger). Pork out-of-stocks are particularly problematic because retail meat cases typically have fewer pork cuts on display than beef cuts or chicken parts. A National Pork Producers Council study in 1998 showed that pork averaged 29.0 percent out-of-stocks during peak shopping hours, compared with 16.0 percent for beef and 7.5 percent for chicken (Messenger). The low rate for chicken is attributed to the higher number of case-ready products. Ready-to-stock meats reduce the frequency of out-of-stocks that are due to labor shortages and inexperienced workers in the meat department.

Large supplies of uniform, precooked, further-processed products also are required to meet the needs of the foodservice sector. According to the National Pork Producers Council, pork use by the foodservice sector, including bacon-topped sandwiches, rib dinners, and ham, grew 17 percent from 1996 to 1999 (Smith, February 18, 2000). This increase was more than double the growth in volume experienced by the foodservice sector as a whole. Since 1995, the number of new pork items on menus has more than doubled

(National Pork Producers Council, February 2000). Currently, pork receives more menu mentions than any other meat, except for chicken.⁴⁶

Potential for Further Research on Incorporating Benefit Effects

According to Williamson (1999), most, but not all, predictions from TCE have been found to hold when production costs (which are affected by resource allocations) also are considered. However, Williamson acknowledges that transaction and production costs should be considered together. One implication of considering benefit effects is that transaction costs may not change with different methods of vertical coordination, or may increase to exploit potential benefits. The shift from farrow-to-finish hog production operations to highly specialized, large-scale operations illustrates this point. Production stages in traditional farrow-to-finish operations are vertically integrated. A single producer located at a single site conducts all stages of production, from farrowing to finishing. Producers that specialize in distinct phases of production at separate locations are “disintegrating.”⁴⁷ The larger producers tend to own the farrowing operations because labor is more specialized and investment decisions are more critical (Martin, 1999). Grower-owned facilities under production contracts with the larger producers are then used to finish or nurse the pigs. While coordinating through production contracts (for example, drafting and monitoring agreements) carries costs, these costs are apparently outweighed by benefits from vertical disintegration. Benefits are derived from scale economies, specialization of capital resources, disease control, specialized labor and management, and manure dispersion. Large producers that specialize in certain phases of production can spread capital over more production units, hogs, and management services and still maintain significant control over production. Employees specialize in specific functions, focusing on breeding, feeding, health maintenance, and other areas.

⁴⁶An apparent decline in the demand for pork since the 1970s appears to have stabilized in more recent years (Martinez, 1999). Based on the pork demand index (fig. 15), demand for pork has increased 11 percent since 1995. In 1999, per capita pork consumption reached its highest level since 1981.

⁴⁷According to Langlois, firm disintegration due to costs of vertical integration has received relatively little attention.

To account for “neoclassical” production costs (productivity) in the TCE framework, Williamson (1979; 1985) establishes a framework whereby firms choose open market production or vertical integration to minimize the sum of transaction costs and production costs. According to Dietrich, however, transaction costs and production costs cannot be summed in such an ad hoc fashion. Transaction costs depend on humans’ limited cognitive abilities (bounded rationality), while neoclassical production costs do not.

Dietrich asserts that TCE is an inherently static approach. If attributes of a transaction do not remain invariant when contracts replace open-market production, then the transaction costs involved (for example, monitoring activity) cannot be defined. In other words, when comparing the effects of alternative methods of vertical coordination on transaction costs, the underlying characteristics of the transaction must not change. This condition is equivalent to assuming that benefits from resource allocations must not change (for example, productivity improvements, ability to control economic processes). These benefits are based on how resources are used rather than simply efficient allocations with given technology and product characteristics. To avoid considering benefit effects, one must assume a general organizational equilibrium (that is, equality of conditions before and after a contract agreement or other change in vertical coordination), so that there is no incentive to adjust coordinating arrangements. Such an assumption requires an ex ante understanding of relevant issues or conditions or an

understanding that does not require changing based on actual events.

Because methods of vertical coordination may be influenced by benefit effects, Dietrich further suggests placing transaction cost economics in a “dynamic” setting, where change unfolds rather than being specified ex ante (Dietrich).⁴⁸ In this case, the general organizational equilibrium loses its significance, and vertical coordination need not rely solely on reducing transaction costs.

To introduce a dynamic element into the analysis of vertical coordination, concepts from resource-based theory (RBT), pioneered by Penrose, may be useful (Mahoney and Pandian). RBT views the firm as a unique pool of productive resources and attempts to model the sources of sustainable competitive advantage. A reallocation of resources, which include physical capital, human capital, and organizational capital, creates benefits that may be viewed as a way for a firm to achieve a sustained competitive advantage.⁴⁹ Translating TCE into the RBT framework would view the firm as both a pool of productive resources and an administrative organization (Mahoney and Pandian).

⁴⁸In his 1999 article, Oliver Williamson, a pioneer in the area of transaction cost economics, concurs that transaction cost economics could benefit from a more dynamic approach. However, he also suggests that such an endeavor will not be easy and will require working “through the mechanisms of economic organization in a slow, molecular, definitive way” (p. 1101).

⁴⁹Organizational capital includes decisionmaking processes, coordinating systems, training, and routines (Westgren).

Conclusions

Transaction costs affect decisions to contract or vertically integrate in the poultry, egg, and pork industries. Spot-market trading is less feasible in markets characterized by (i) new and specialized technology in thin markets with few producers and processors, (ii) close proximity of producers and processors, and (iii) important scheduling and timing factors related to raw product deliveries. These situations expose investors to hazards related to unscrupulous behavior by other parties. Furthermore, measuring quality attributes of raw product inputs is more costly if the attributes are difficult to observe or if a significant premium is placed on quality and consistency of inputs. These conditions provide incentives for contracts and vertical integration.

Relationship-specific investments, and market uncertainty from a number of sources, including (i) technological advances, (ii) price and quantity instability, and (iii) lack of communication between parties at different vertical stages of the production process, can influence the type of contract or the decision to vertically integrate. Uncertainty, coupled with relationship-specific assets, creates incentives for contracts that adjust automatically to changing market conditions. As the degree of uncertainty increases, contracts should be used that provide the contractor with greater control over production. When uncertainty or relationship-specific investments are especially severe, processing and production should be coordinated through vertical integration. Contracting practices and vertical integration in the poultry, egg, and pork industries support these assertions.

What are the implications for assessing rapid changes in coordinating arrangements currently underway in agricultural industries, such as the pork industry? Policymakers can indirectly influence pressures to enter production contracts and vertically integrate based on how policies are shaped, enacted, and enforced. Laws and regulations can affect firm strategies and the competitive environment in which firms operate. Uncertainties and inconsistencies related to enactment and enforcement of antitrust and environmental policies make it increasingly important that firms find ways to adapt to changing policy situations. Firms can adapt through vertical integration or contracts designed to reduce haggling and provide greater control over the vertical stages in production.

In the pork industry, most marketing contracts between “independent” producers and processors are directly related to a spot price, such as the Iowa/Southern Minnesota quote, which facilitates adaptations to the changing market. However, spot prices may become less reliable indicators of market conditions as less trading occurs on spot markets, which may lead to conflicts between producers and processors. Further-more, the ability of large buyers and sellers to manipulate spot prices is enhanced because spot prices will be based on fewer trades. Unless alternative base prices are found, producers and processors will seek greater control through production contracts or vertical integration. Prices from a thriving spot market, perhaps a wholesale price, that can serve as a base price in a marketing contract would enable producers to survive as separate entrepreneurial entities. This arrangement suggests a role for public programs that collect and distribute market information to ensure a vibrant spot market.

In addition to reducing transaction costs, contracts and vertical integration are also associated with gains in production efficiency and more value-added product offerings of consistent quality. These arrangements could facilitate important investments in cost-reducing technology and value-added production that may have been otherwise delayed. The effect of combined production efficiencies and tailored product offerings on demand and consumption are likely to vary across industries. However, continual progress in responding to consumer tastes and preferences can facilitate an industry’s competitiveness at home and abroad through cost savings and sustained demand. Policies designed to restrict business arrangements may, in fact, inhibit industry growth and hasten the exit of firms as fewer firms are able to compete.

Benefits derived from contracts and vertical integration also have implications for the framework used to evaluate these arrangements. Further research might extend the TCE paradigm to incorporate both transaction-cost economizing principles and benefits derived from new resource allocations. While empirical studies generally have supported the TCE theory (Williamson, 1999; Shelanski and Klein), such a combined framework may provide greater explanatory power regarding various types of vertical coordination in a variety of different industries.

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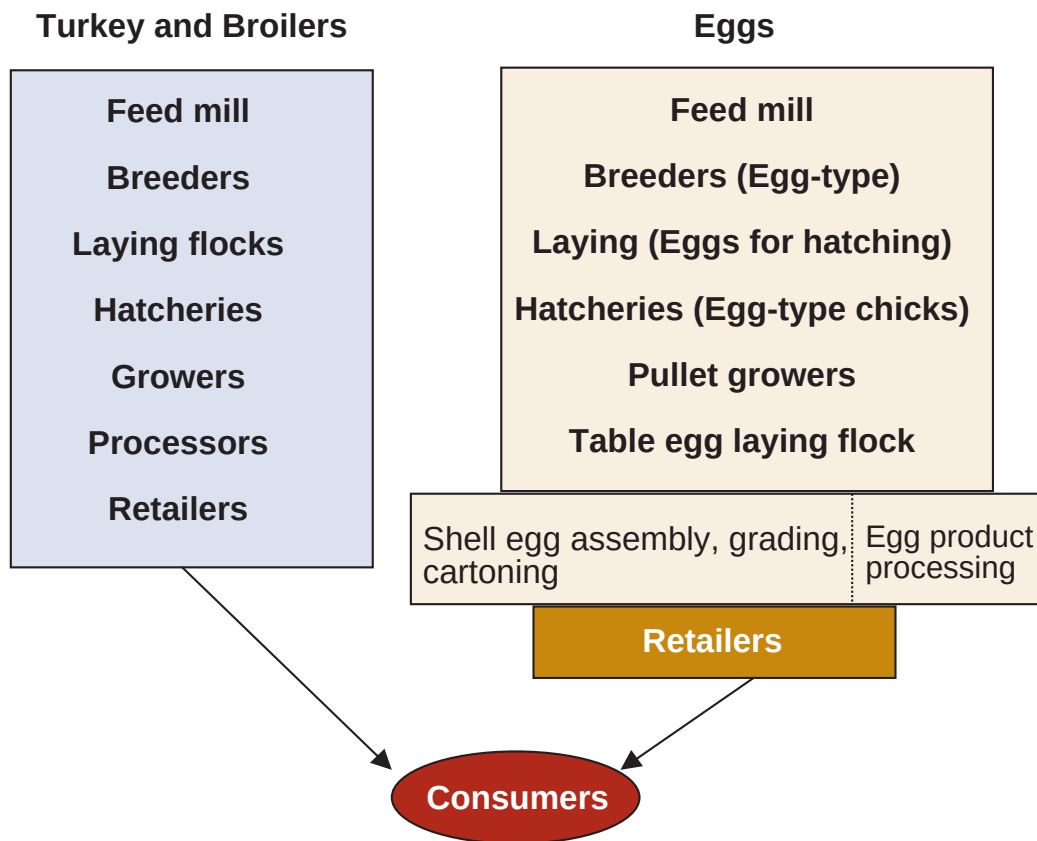
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Appendix A: Vertical Stages of the Poultry and Egg Industries

The poultry production and marketing process consists of several stages. Company-owned feed mills are used to manufacture feed for the various stages. Breeder farms specialize in producing the generations of male and female strains. Breeder flocks are raised to produce male and female pullets that are sent to breeder houses. Eggs are produced and sent to hatcheries. Chicks from the hatcheries are moved to the growing stage, where they are raised to slaughter size. After processing, products are sent to distribution centers and then transported to customers.

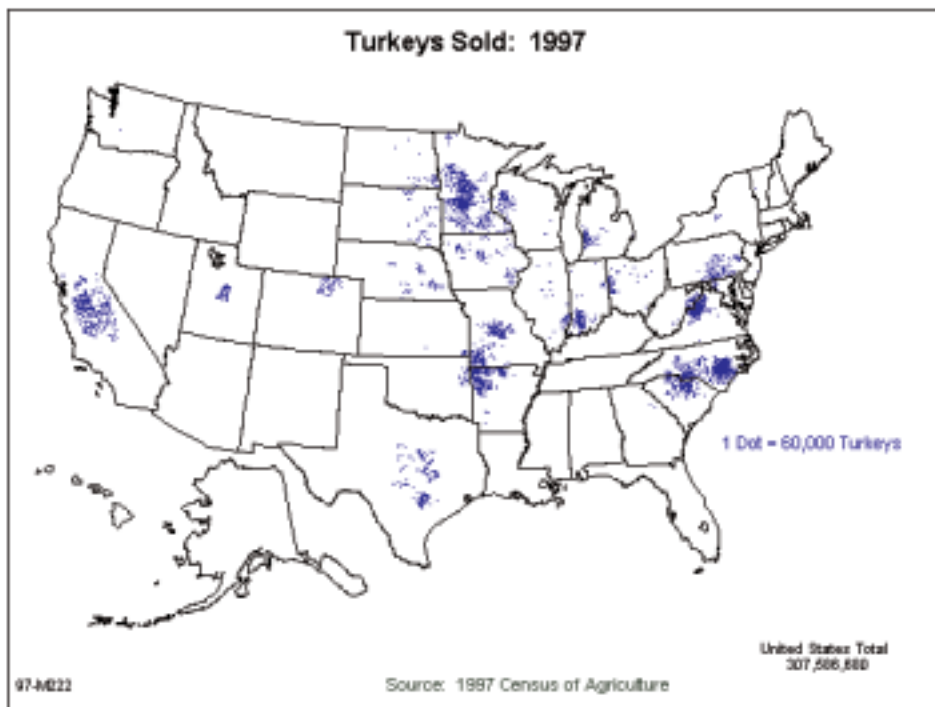
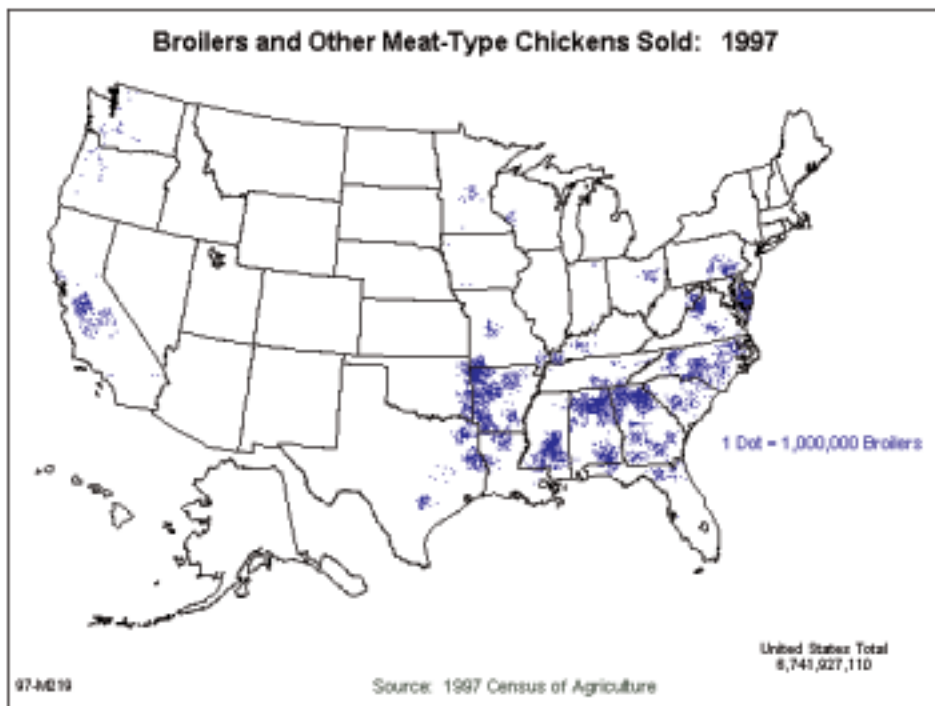
In the table egg industry, egg-type chicks are hatched and grown to produce laying hens. These hens produce the eggs that are cleaned, graded, and packed for the fresh shell egg market. Table eggs are then transported to retail distribution centers. Eggs may also be further processed into value-added products, such as liquid eggs, and reach the consumer through retail or institutional outlets.



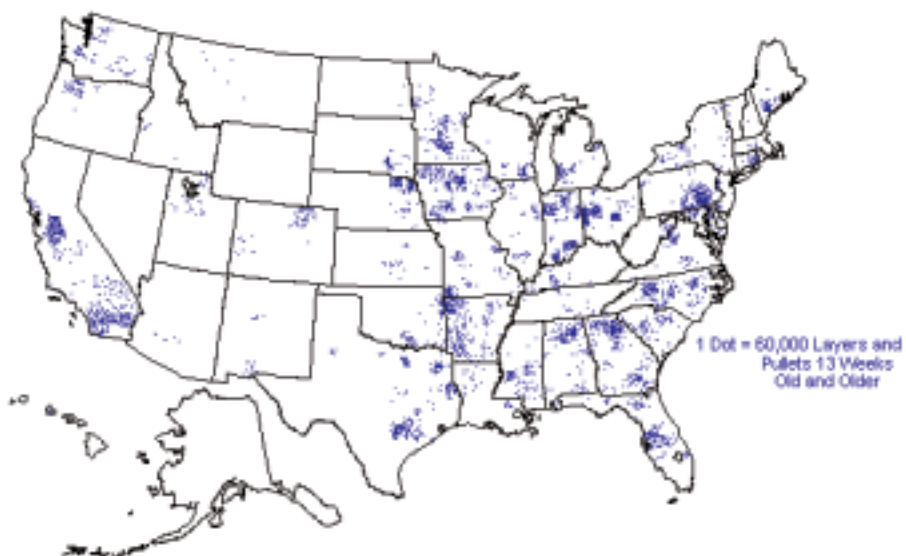
Appendix B: Geographic Region Definitions

Region	States
Northeast	Maine, New Hampshire, New York, Rhode Island, Connecticut, Pennsylvania, Vermont, Massachusetts, New Jersey
North Central	
East North Central	Illinois, Indiana, Ohio, Wisconsin, Michigan
West North Central	Iowa, Minnesota, Missouri, Kansas, Nebraska, South Dakota, North Dakota
South	
South Atlantic	North Carolina, South Carolina, Georgia, Virginia, Florida, West Virginia, Maryland, Delaware
South Central	Alabama, Mississippi, Oklahoma, Texas, Tennessee, Kentucky, Louisiana, Arkansas
West	Washington, California, Utah, Oregon, Montana, Idaho, Nevada, Colorado, New Mexico, Arizona, Wyoming

Appendix C: Location of Broiler, Turkey, Egg, and Pork Production, 1997



Layers and Pullets 13 Weeks Old and Older - Inventory: 1997

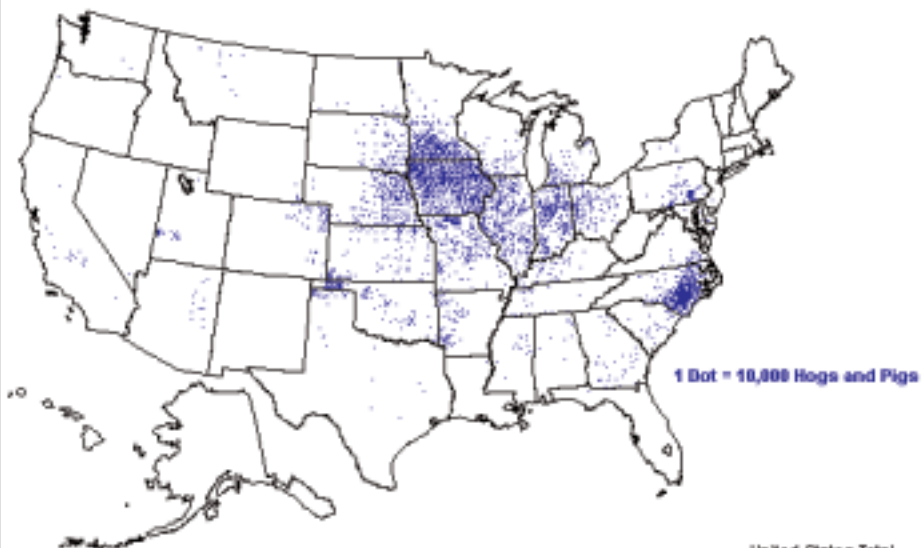


United States Total
366,669,851

97-M198

Source: 1997 Census of Agriculture

Hogs and Pigs - Inventory: 1997



United States Total
61,206,236

97-M198

Source: 1997 Census of Agriculture

Appendix D: Demand Index Calculations

Demand indices are calculated using annual per capita consumption (1979-99), annual deflated retail prices (1979-99), and a demand elasticity (app. table 1) in the following steps (Purcell):

1. To obtain an estimate of the annual percentage change in retail price associated with the corresponding change in per capita consumption, the annual percentage change in per capita consumption is divided by the demand elasticity.
2. The “demand constant price” is calculated by adjusting the deflated retail price by the percentage change in price from step 1.
3. The percent difference between the actual deflated retail price and demand constant price is calculated.
4. Demand indices are then calculated by first setting the 1979 index equal to 100. The 1979 index is adjusted by adding the percentage difference calculated in step 3 for each year.

Appendix table 1—Retail demand elasticities

Broilers	Turkeys	Egg	Pork
-.5308	-.6797	-.1452	-.7297

Source: Huang, K.S. 1985. *U.S. Demand for Food: A Complete System of Price and Income Effects*, Technical Bulletin 1714, U.S. Department of Agriculture, Economic Research Service.

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