

Price Discovery & Risk Management in an Industrialized Pork Sector

David Kenyon and Wayne Purcell*

Introduction

The process of industrialization in the swine industry has been written about extensively in recent years by Grimes, Barkema and Cook, Hurt, Rhodes, Boehlje and Schrader and others. The purpose of this paper is to concentrate on the pricing issues that have arisen during this process of industrialization. These issues include the diminishing role of open competitive markets and the increasing role of carcass value pricing, contracting, vertical integration and coordination, and marketing supply contracts.

As the marketplace changes, a critical question emerges: “Who is going to manage the price risk so inherent in the hog sector, and how are the risk exposures changing?” The answer to this question has important implications to all segments of the pork sector, including agribusiness firms, the futures exchanges, policy makers, regulatory agencies, environmental groups, and the general public as it debates the course the swine industry is currently taking.

The ideas in the paper are gleaned from research on the swine industry in the Southeast since 1980, a review of trade publications, academic papers, journal articles, and a synthesis of these ideas within an economic theory framework. These varied information sources are used to understand what has happened, what is happening, and what might happen in the next 10 years. With changes in structure come possible changes in firm behavior and a changed economic outlook for every participant from producer to processor to the agribusiness firms supplying inputs and management services. Future business plans and efforts to influence policy and regulatory decisions require some ability to anticipate what that future will hold.

Conceptual Model

Many factors have led to industrialization in the swine industry. Some of these include changing consumer tastes and preferences (Hurt), profitability of hog production, (Hayenga *et al.*, Grimes, Lawrence), consolidation in the hog packing sector (Karlson and Eidman) and access to and control of information (Boehlje and Schrader). Organizing these various factors in terms of their role in fostering industrialization, their relative importance in the process, and understanding where this process is headed is difficult. Industry and academic economists have attempted to explain this process with only modest success. Reimund, Martin, and Moore (RMM), in 1981, developed a model of structural change after careful consideration of the structural changes that had occurred in the broiler, beef, and vegetable industries. Their model can be used to help organize an analysis of the origin, process, and future of industrialization in the swine industry and to give insight into future market structure, especially in the areas of price discovery and risk management.

* Professors in the Department of Agricultural and Applied Economics, Virginia Tech, Blacksburg, Virginia.

The RMM model first identifies important economic factors initiating changes in structure, and then examines the process of structural change flowing from these initial changes. Structural change is defined as a significant change in the ownership, control, and organizational characteristics of resources used in the production of a commodity. The important factors initiating structural change in the RMM model are 1) various forms of technological improvement (mechanical, biological, and organizational), 2) resource and product market changes, and 3) policy factors. Once one or more of these factors initiate structural change, the RMM model suggests that the industry will pass through several stages on its way to becoming more industrialized.

These RMM model stages are outlined in Table 1 and are 1) technological change, 2) shift in production location, 3) growth and development, and 4) adjustment to risk. Reimund, Martin, and Moore identify some of the changes that occur in each of these stages. Not all commodities would be expected to exhibit every change identified under the four stages.

Table 1. Structural Change Model for Agricultural Subsectors

I.	<p>Technological change stage</p> <ul style="list-style-type: none"> • New technology adopted by large producers • Capital requirements increase • Economies of size develop
II.	<p>Shift in location of production stage</p> <ul style="list-style-type: none"> • New producers and new capital enter in new producing areas • Interregional competitive advantage shifts to new areas • Production begins to concentrate in new areas • Producers in new area use new technology
III.	<p>Growth and development stage</p> <ul style="list-style-type: none"> • Innovative and aggressive entrepreneurs develop larger farms using new technology • Specialization and concentration in production occur • Market economies develop in all stages of subsector in new area • Output per farm grows rapidly • New information systems develop • Rapid growth and concentration alters risk • New producers are risk takers, aggressive, and innovative • Periods of overproduction amplify market risks
IV.	<p>Adjustment to risks stage</p> <ul style="list-style-type: none"> • New risk aversion strategies • New types of coordinating procedures are established • Use of forward sales and production contracts increases • More coordination develops • Control of product flows and product characteristics shifts from producers to nonfarmers or other stages of the food and fiber sector closer to the final consumer • All stages become more industrialized

Source: Reimund, Martin, and Moore, *Structural Change in Agriculture: The Experience of Broilers, Fed Cattle, and Processing Vegetables*, USDA, ERS, Tech. Bul. No. 1648, April 1981, pp. 54-55.

The RMM Model and Swine Structural Change

The researchers applied their model to the swine industry in 1981 because it was frequently cited as a sector likely to undergo major change. They identified the initiating conditions for structural change as development of improved “lean” breeds of hogs, development of environmentally controlled production facilities, and advances in nutrition and animal health practices. These advances made it possible to develop large-scale production units that could utilize new technology and achieve economies of size. The authors did not include changing consumer demand or consolidation of the packing industry as a factor initiating structural change in the swine sector.

The large-scale specialized production enterprises using the latest technology did in fact start, as the model predicted, outside the traditional hog production regions, primarily in North Carolina. Many of the new producers were integrated with feed manufacturers. Large-scale operations, those marketing more than 5,000 slaughter hogs per year, accounted for 1/6 of U.S. total marketings in 1978, but their output was increasing 17 percent per year (Rhodes, Stemme, Grimes). In the context of the RMM model, the swine sector was passing through stage 1 of adopting technological change and entering into stage 2, the “shift in location.” There was developing evidence that these new large production units were growing faster than the more traditional and smaller production units.

Several other studies in the 1970s and 1980s helped document the initial causes and characteristics of large specialized production units. A 1973 North Carolina study by Ikerd and Higgins found contracting was being used by feedmills to develop or maintain a dependable market for feed and by packing plants to keep their plants running near capacity and to upgrade the quality of hogs processed. Rhodes and Grimes reported that North Carolina was the leading state in number of producers marketing more than 5,000 head per year in 1974. These large units had grown by 276 percent from 1965 to 1974. Van Arsdall reported that Southeast hog producers with annual sales over 2,500 head achieved average feed conversions of 3.15 compared to an average of 4.43 in the North Central region. In 1980, Van Arsdall and Nelson reported that 16.5 percent of hog sales were from farms with sales over 2,500 head per year in the Southeast. The comparable percent for the North Central region was 6.8 percent.

Kenyon and Mundy used the RMM model in 1982 to analyze the Maryland, North Carolina, Pennsylvania, and Virginia swine industry employing a mail survey of producers and personal interviews with packers and feed manufacturers. Like Reimund *et al.*, they found considerable evidence of stage 1 technological and biological change and stage 2 growth of large firms. In 1982, 4 percent of the hog producers with annual sales exceeding 2,500 head were producing 36.8 percent of the hogs in the region. Seventy-four percent of the farms in North Carolina selling more than 25,000 hogs annually were specialized in hog production. Producers reported receiving premiums from packers for selling full track loads of hogs on a regular basis. Over 20 percent of the North Carolina hogs were produced under production contracts with feedmills. The contracts provided for a payment per head plus a premium for feed efficiency. In 1982, packers were not widely involved in contract production with producers. Thus, in the RMM model, the North Carolina swine industry had completed stages 1 and 2, was in the middle of stage 3 exhibiting rapid growth, and was showing some early signs of stage 4 where new price risk management arrangements would be expected.

These early studies concentrated on innovations and changes at the producer level as the driving force behind expansion of new, large, efficient production units using the latest genetics, feeding, and animal health programs. The packing companies in the 1970s and early 1980s were not heavily involved with these new producers in terms of ownership or interlevel coordination, and the changing needs and desires of consumers were seldom mentioned as a driving force for change in the pork industry. Economic analysis supports a conclusion

that during the 1970s and through the mid-1980s, the driving force behind the rapid increase in large production units in the U.S. was the profits to be made in the evolving large swine production operations.

Using historical producer data from Iowa and Nebraska, Brumm reported that returns to capital in pork production was the reason for the “massive” capital movement into pork production in the 1980s and 1990s. According to Brumm, rates of return averaged 26.7 percent in Iowa and 18.7 percent in Nebraska from 1988 to 1994. The top one-third of producers averaged 40-50 percent rates of return (Table 2). Operations marketing 1,800 hogs per year were showing profits of \$44,000 to \$50,000 per year. In North Carolina, the Swine Demonstration Project, operated as a 120 sow commercial farrow-to-finish facility using the latest available technology, averaged returns to labor and management of \$9.10 per cwt from 1979 to 1990 (Kenyon and Thornsby). Sony Faison, President of Carrolls’ Foods, Inc., indicated the company averaged 10 cents per pound profit in their swine operators from 1990 to 1994 (*Business North Carolina*). These and other similar data prompted Hurt; Hayenga *et al.*; and Grimes and Rhodes to also conclude that the rapid increase in large confinement swine facilities and mega producers (over 500,000 per year) has been a response to profit potential in swine production.

In 1993, only 3 percent of U.S. hog production was vertically integrated with packers through ownership of production facilities (Rhodes). About 13 percent of U.S. production was marketed by 57 producers in 1993 (Rhodes and Grimes). Seven large firms each marketed more than 500,000 head and planned to grow at a rate of more than 20 percent per year. These large firms were located outside the Midwest. According to the RMM model, structural change was initiated by technological change in production technology (stage 1), moved to non-traditional production areas (stage 2), and entered a period of rapid growth characterized by economies of scale and large profits (stage 3). As the RMM model indicates, the rapid growth and concentration change risk exposures during stage 3 and cause a search for new ways to manage risks and coordinate production, packing, and retailing within the system during stage 4 of development. There are a number of changes occurring in the pork sector over the last 5-8 years that indicate the swine sector is attempting to deal with the price and risk management issues that are predicted in stage 4 by the RMM model.

Pricing and Risk Management Issues

As industrialization of production was occurring in the 1970s and 1980s, the hog packing sector underwent a tremendous restructuring. Between 1980 and 1985, at least 11 major hog slaughter plants closed. These plants had a combined annual kill capacity of 9.7 million hogs. Most of these plants were older, multi-storied plants (Karlson and Eidman).

The older plants were replaced by newer plants with improved efficiency. Output per production worker rose and the new plants created excess capacity relative to hog supplies. Hog packers looked for ways to improve margins, and turned to reducing labor costs. Iowa Beef Processors, Inc. (IBP) entered hog packing in 1983 and used non-union labor earning \$4.00 per hour less than most other packers. These lower wages caused other packers to demand wage concessions. From 1977 to 1986, real wages in meat packing plants declined 31 percent (Table 2). By the mid- 1980s, the hog packing industry was substantially modernized with much lower labor costs (Karlson and Eidman).

Table 2. Real Earnings of Production Workers in Manufacturing and Meat Packing: 1977-1986

Year	Manufacturing (SIC Division D)	Meat Packing (SIC 2011)
	\$/hour	
1977	\$9.37	\$10.84
1978	9.46	10.87
1979	9.23	10.65
1980	8.82	10.30
1981	8.79	9.87
1982	8.79	9.33
1983	8.87	9.11
1984	8.85	8.56
1985	8.85	7.53
1986	8.88	7.52
Percent Change 1977-1986	-7%	-31%

Source: Karlson, N. and V. Eidman, *Structural Change in Meat Packing and Processing: The Pork Sector*, Dept. of Agric. & Applied Econ., Univ. of Minn., SP P91-31, July 1991, p. 19.

Carcass Value Pricing

With modern, lower cost plants, packers began to look for other means of reducing costs and improving margins. Packers knew that excess fat was costly to remove and that the new health conscious consumer wanted less fat. But the existing open market price-based system of yields and grades was not sending signals to producers to reduce fat in market hogs. Hayenga *et al.* reported that only 10-12 percent of all hogs sold to packers during 1984 were priced according to actual carcass performance using carcass merit evaluation pricing systems. The researchers demonstrated that a carcass value pricing system based on carcass weight, backfat, and muscle score could explain 79 percent of the variation in carcass value compared to 58 percent in a typical live-hog procurement system. They concluded that a carcass merit pricing system could be easily implemented by packers and would provide producers with clearer signals concerning consumer demand for lean pork.

Hatfield Packing Co. of Pennsylvania, John Morrell & Co., and Geo. A. Hormel & Co. were among the first packers to use objective carcass merit buying programs in the late 1980s (*Feedstuffs*, 1/4/94). Jeff Luckham, procurement director for John Morrell, indicated Morrell was the first major packer to introduce a lean payment program in 1989. After introducing the program, average percent lean increased 3 percent in three years. Luckham indicated consumers were forcing all packers to produce a better product (*Feedstuffs*, 2/2/92). Adoption of carcass value pricing (CVP) caught on quickly among other packers. In 1990, 25 percent of all hogs were purchased via CVP (Schroeder). By 1993, 75 percent of all hogs were purchased under a carcass merit system (NPPC Pork Chain Quality Audit).

All CVP systems include premium and/or discount schedules for backfat and weight categories. Some CVP programs include premiums and discounts for loin eye muscle depth, although these adjustments are generally much smaller than those for weight and backfat. Packers have consistently argued that variation in live hog quality is their number one problem (Table 3). Table 4 documents that in 1993 the variation in hog weight, backfat thickness, and carcass muscle was large, with over one-third of all animals outside the desired ranges in CVP systems as reported by Kenyon, McKissick, and Lawrence. More than one-third of the live hogs weighed less than 220 pounds or more than 260 pounds, more than one-half had backfat greater than one inch, and more than one-third had carcass muscle less than 48 percent of carcass weight. The extreme variability that packers

faced in live hogs made it very difficult for packers to produce uniform, consistent, high quality pork products that consumers desire. The variability was a major barrier to quality control and to the ability of the sector to move toward "consumer friendly" status.

Table 3. Packer Perception of Hog and Carcass Variation Problem

<p>In a single truckload of hogs, backfat typically varies between 13 and 43 mm (0.5-1.67 in). -- D. K. Spell, procurement director, Lundy Packing Co., <i>Feedstuffs</i>, Feb. 2, 1992</p> <p>U.S. packers are complaining that variation, not leanness, is the number one problem for them. -- <i>Feedstuffs</i>, June 7, 1993</p> <p>A typical trailer load of hogs comes from 29 producers. An average load of hams is derived from more than 50 herds. Those statistics underscore the pork industry's biggest hurdle in attaining better quality product. Excessive variation in genetics, management, nutrition, ... -- Derrick Gee, PIC, <i>Feedstuffs</i>, Nov. 15, 1993</p> <p>There is too much variation between hogs and there is probably more variation today than a few years ago. -- Alan Schinckel, Purdue University animal scientists, <i>Feedstuffs</i>, Dec. 6, 1993</p> <p>American Meat Institute, packers, processors and retailers all ranked lack of uniformity in live hogs, carcasses, and retail cuts as second or third most important quality issue facing the industry. -- NPPC, Pork Quality Audit, April 1994</p> <p>Our hogs are like peas in a pod, and that is very important to the Japanese. They are looking for a lean, uniform product in a given volume, and we are able to satisfy that demand. --Jeff Luckham, director of procurement, Smithfield Foods, Inc., <i>Feedstuffs</i>, May 23, 1994</p>

Table 4. Hog and Carcass Variation in Weight, Backfat, and Percent Lean

Category	Units	Percent
Liveweight	< 220 lbs	8.8
	221 - 240	32.7
	241 - 260	33.2
	261 - 280	17.5
	> 281	7.9
Backfat thickness, last rib	< .60 inch	3.0
	.60 - .79	11.5
	.80 - .99	21.2
	1.00 - 1.19	27.6
	1.20 - 1.39	17.1
	1.40 - 1.59	10.9
	1.60 - 1.80	6.5
1.80 +	2.2	
Carcass muscle, percent	< 45%	11.6
	45 - 47.9	21.8
	48 - 50.9	33.8
	51 - 53.9	19.8
	54 - 56.9	10.7
	> 57	2.3

Source: NPPC, *Pork Quality Audit*, April 1994, pp. 32-33.

Under most CVP systems, the base carcass price is formula driven relative to live cash prices reported in the Iowa-Southern Minnesota market (Kenyon *et al.*). These live prices are used to compute an equivalent carcass price using a formula that varies by firm. But in most cases, the price in early 1997 was still being discovered in the live market rather than the carcass market. All packers but one in the southeastern region of the U.S. were determining their base carcass price off the Iowa-So. Minnesota or other Midwest live cash prices. Hog prices in the U.S. were still primarily discovered in the cash market in Iowa-So. Minnesota where there remain many producers and a number of packers aggressively bidding for hogs (Clanton). That market area did not move to use of price reporting based on carcass yield of lean until 1999, and both carcass-based and live-based prices and price ranges are still being reported by the USDA.

The CVP system is designed to communicate to producers the quality of their hogs by paying higher prices for lean, meaty hogs of desired weight. The implementation of CVP has reduced backfat levels among hogs, but there is considerable evidence accumulating that indicates many packers do not believe that the open market price system alone can generate the quality and consistency of hogs they desire. Several packers have purchased or made arrangements with genetic seed stock companies. Smithfield Foods has exclusive rights to NPD genetics in the U.S. According to Joe Luter, III, President and CEO of Smithfield Foods, Inc., the NPD pig is the cornerstone of Smithfield's long range strategy. The NPD is lean, long, and muscular, with half the backfat and with hams that are 33 percent leaner than the average pig processed at Smithfield prior to the investment in the new genetics. The "remarkable animal" has superior conversion and productivity and quality assurance traits, and each animal has its entire history documented (*Feedstuffs*, 8/23/93). Farmland Industries requires all producers in their "uniform pork" program to use DeKalb genetics (*Feedstuffs*, 9/25/95). Expansion by Seaboard Farms in Oklahoma and by Circle Four in Utah all involved a complete integration of production and processing. These integrated or coordinated firms use only one or two genetic lines to improve the uniformity of their hogs and processed products. The expansion of operations that are using specific genetic lines in the last several years suggests that the carcass merit pricing systems alone have not been sufficient to improve the quality and uniformity of hogs to the level desired by packers.

Marketing Supply Contracts

Marketing supply contracts are offered by packers to producers to guarantee supplies, to improve uniformity, and to improve overall quality. Producers use market supply contracts to assure market access and to obtain higher prices. Most supply contracts are 4 to 7 years in duration, and several require that the producer sell the packer at least 10,000 hogs per year. In early marketing supply contracts, the transaction price was based on the live hog market price the day hogs are delivered, but contracts are moving rapidly to carcass-based pricing. Some contracts have "price windows" that permit the packer and processor to share price risks above and below a predetermined high and low price. Some market supply contracts provide a premium on all hogs sold, although the amount of this premium is not generally known. Packers justify this premium on the basis of reduced purchasing costs and reduced hog supply variability that reduces their operating costs.

Only 5 percent of Iowa producers reported being involved in a long-term supply contract in 1994, according to a survey conducted by Lawrence. About a third of those with marketing contracts had a price window provision. There were then few if any risk-sharing provisions in most of the contracts. Some contracts require minimum meat quality standards and some state minimum genetic standards. Eighty-three percent of the hogs in the survey were sold on the live cash market.

Early marketing supply contracts did not change the traditional price discovery process for hog prices since prices were still based on Midwest live hog prices. These contracts improved coordination between producers and packers, but they do not fundamentally change how prices are being discovered. In addition, the decision to expand or contract production still lies with the producer, although signing a marketing contract may

put some constraints on production decisions. Marketing supply contracts may improve coordination between producer and packer, but they do not increase the level of vertical integration in the industry so long as packers do not own production capacity and producers do not own processing capacity. This continues to be true as the transition to carcass-based pricing in marketing supply contracts proceeds.

Price Window Contracts

Price window contracts have been available to producers for approximately five years. According to Grimes and Rhodes, only 1.3 percent of U.S. hog production was covered under a price window or cost plus contract in 1994. Under these contracts, the packer specifies a price window within which the producer receives the market price. Typical price windows are \$40-48 cwt, \$40-50 cwt, \$38-48 cwt, etc. Above the high price, the producer receives 50 percent of the amount the price exceeds the high price. During high price periods, producers receive prices lower than the market price and packers pay lower prices. Since pork packing margins are typically squeezed and frequently negative during periods of high prices, the packer benefits during these periods of high prices. When prices are below the window price, the producer receives the lower window price minus 50 percent of the difference between the window price floor and the market price. During periods of low prices, producers receive higher prices, which helps improve returns and cash flows. The packer pays higher prices during periods of low prices, but historically processor margins are better during periods of low prices. Hence, the price window contract should theoretically benefit both producer and packer by helping level out cash flows over time. Reduced farm level price variation may lead to less quantity variation over time, making it possible to improve the quantity coordination between producer, packer, and retailer by maintaining a more consistent flow of product at lower operating costs.

Hog Price Cycle

Hog prices have traditionally been very seasonal and cyclical at the farm level. Grimes (*Feedstuffs*, May 27, 1996) and some other economists argue that the traditional hog cycle indicators and hog:corn ratios are no longer good guides to producer response to prices and returns. They argue that industrialization of hog production and coordination between the producer and packer has altered historical relationships. These relationships may have been altered in recent years, but the extremes in prices have not been eliminated. Since 1994, the industry has experienced \$28 cwt prices in November 1994 followed by \$55-60 cwt prices in the summer of 1996 and 1997. A huge surge in production strained the capacity of the packing/processing sector in late 1998 with daily prices below \$10 per hundredweight on a live hog basis. These low and high prices are in line with or exceed previous cycle highs and lows since 1975. The industrialization and coordination that occurred in the industry through the late 1990s have clearly not made much of an impact on price risks at the producer level.

The industry has, apparently, made some progress in reducing monthly slaughter variation since 1970. From 1970 to 1979, the coefficient of variation in monthly slaughter within a year ranged from 6.5 to 13.3 percent. Since 1979, the coefficient of variation has generally been below 10 percent each year and averaged 6.7 percent during 1992-1996 before increasing again coming into the volatile prices in 1999. The increase in variation during 1975-1979 when corn prices were relatively high and the reduction in variation in 1985 and 1986 when corn prices were low would suggest at least part of the variation is induced from feed cost variability since feed costs typically make up about 60 percent of the cost of producing hogs. Volatile corn prices in 1996, when record high levels were recorded, were again associated with more volatile hog prices.

Although variability in the swine production system, as reflected in coefficients of variation appear to be trending down, is declining over time, there is still substantial price risk. The price plunge of late 1998 reaffirmed the presence of huge price risks to the producer. The vertical integration and coordination that have occurred to

date have not, it appears, brought a substantial reduction in producer price risk. Producers and packers within the system are very concerned about how to manage this risk, especially after experiencing \$5.00 per bushel corn prices during 1996. At \$4.00-5.00 corn prices and \$40 hog prices, even large specialized efficient hog producers lose money.

Smithfield Foods, Inc., has a stated risk management strategy: to integrate production, packing, and processing (*Feedstuffs*, 8/28/95). When production margins are low, packing margins are usually favorable and vice versa. By owning some production (Carrolls' of Virginia; Browns, Inc.; Circle Four), Smithfield Foods, Inc. hopes to level out company earnings over time. But the large mega producers and other large producers will have to use other means of price risk management. Carrolls Foods, Inc., expected price volatility to continue in the industry (*Feedstuffs*, 5/15/95), and those expectations proved correct. The huge losses the company incurred during record high corn prices in 1996 and record low hog prices in late 1998 brought acquisition by Smithfield Foods, Inc. Rhodes suggests that large specialized production units will have to develop financial reserves to survive the low price phase of the hog cycle because they lack, as specialized producers, other income sources to support them during periods of low hog prices. These large specialized farms should have the expertise to use hog, corn, and soybean meal futures and options to manage their margins, but the evidence of the 1996-1998 period suggest that some do not have effective price and cost risk management programs. Clay and Kenyon have demonstrated that profit margin hedging strategies can be used to stabilize producer returns. The move from smaller hog-corn-soybean farms to specialized hog farms without a crop base will likely increase the demand for futures contracts, options on futures, and other risk management instruments.

Hog Futures Market

The Chicago Mercantile Exchange (CME) changed their live hog futures contract to a lean hog futures contract starting with the February 1997 contract. The new contract is based on wholesale prices of 51-52 percent lean pork and is cash settled based on the weighted average U.S. carcass price for the previous two days. By switching to a carcass price contract, the CME is indicating that the industry is moving towards pricing at the carcass level rather than the live level. Open interest in the February 1997 contract exceeded open interest in the February 1993, 1994, 1995, and 1996 contracts, indicating that the industry appears to have accepted the new contract, and the growth has continued in later years. The cash settlement provisions should make the contract attractive to exporters and importers as the export market grows in future years. And the new contract should be attractive to large producers who are familiar and comfortable with transaction systems based on carcass prices.

Impact of Consumer Demand

Barkema and Cook argue that changing consumer demand is the driving force behind industrialization in the swine industry. Their argument is that changing consumer tastes and preferences, especially for less fat, more consistency, and less preparation time, have led packers into developing pricing and ownership arrangements that make it possible for them to secure the type of hogs they can process efficiently into the products consumers want. Rhodes and this paper make a strong case that the industrialization of hog production preceded the involvement of packing plants into the ownership and control of hog production. In 1993, only 3 percent of national slaughter was directly controlled by packers. Hence, consumer preference and quality issues do not appear to have been the initial driving force behind the level of industrialization found in production today.

But consumer preferences appear to be becoming a catalyst for change and are playing an important role in some of the pricing arrangements that exist in the industry today. Carcass value pricing by packers is an attempt to get producers to produce less fat, a direct response to changing consumer desires. The substantial discounts for pork carcasses outside the desired weight range are a strong signal to producers that packers want uniform hogs that provide uniform portion size (Kenyon, McKissick, Lawrence). Almost 50 percent of all meals

are eaten outside the home today (Manchester and Clausen). Modern consumers want high quality, consistent, nutritious meals that require little preparation. Growth in food sales is in prepared food products, not fresh products (Hale). These consumer desires make it imperative that packers have uniform, high quality hogs to slaughter and process. The carcass value pricing systems of packers are designed to improve the uniformity and leanness of hogs in direct response to these consumer desires.

But pork quality depends on a number of attributes in addition to uniformity in size and leanness. Consumers are also concerned about appearance, tenderness, juiciness, nutritional value, and food safety. The current CVP systems do not measure these quality attributes. In fact, the industry is concerned that emphasis on leanness has come at the expense of other quality traits important to consumers. According to a survey of Midwestern packers, 15 percent of all hogs processed produce pale soft exudative (PSE) pork (*Feedstuffs*, 2/2/93). The halothane or “stress” gene improves the dressing percentage and increases loin production but can generate color and toughness problems. The NPPC national genetics evaluation study found that 12 percent of all maternal line sows are carriers of the halothane gene (*Feedstuffs*, 6/26/95). The current and developing CVP systems of packers cannot “solve” this quality problem. The way to eliminate this problem is to buy seedstock that is verifiably free of the stress gene. This particular quality problem and others like it help to explain why some packers have entered into the seedstock business or require producers to use a certain genetic line. It is the packers’ way of controlling quality outside the traditional market price system.

Consumers are also concerned about color, marbling, cholesterol, cooking loss, moisture content, tenderness, juiciness, flavor and chewiness. At present, it is not possible to measure most of these attributes in an efficient, accurate, and cost effective manner at packing line speeds. Research is being conducted to determine methods and tests that could be used to include these quality traits in carcass value pricing systems. But until these tests are identified, tested, and adopted, packers will have continued incentives to control or coordinate producer genetics to obtain the quality of pork they desire. Packers who buy from only a few large producers will find it much easier to coordinate or match their raw product quality attributes and the final processed product attributes designed for specific consumer markets. Hence, while quality issues may not have been a driving force in the integration and coordination present in the pork industry to date, they will be a more important factor in the future, especially as the pork industry further expands in the export market. The next growth surge in the industry will come from demand pull rather than the “cost push” of increased efficiencies and economics of size in a consolidated pork industry.

Implications

During the fourth stage of the RMM model, the industry develops new procedures for risk management, especially price risk management, and sharpens the coordination of production with consumer demand. This is clearly the current situation in the pork industry. These changes have been evidenced by marketing supply contracts between packers and producers to help coordinate supplies, quality of offerings, and demand. Price window contracts have been developed to help share the price risks inherent in the hog cycle. Carcass value pricing has been instituted to signal producers to produce a product more consistent with consumer desires. A few packers have entered into production and purchased seedstock companies in an effort to better coordinate pork quality with consumer desires.

Despite the growth of new market coordination mechanisms, the Midwest cash live hog market (especially Iowa-Southern Minnesota) was still, into 1997, the focal point of the price discovery system. The existence of a large number of packers with excess slaughter capacity relative to local supplies of many relatively small producers has generated a very competitive price discovery process in that market area. Almost all other hog prices across the U.S. continue to be tied to these prices (Kenyon, McKissick, and Lawrence). Although about 20 percent of U.S. hogs are produced under contract, the contracting is primarily between very large producers and their contract growers. Most large producers still transfer their market hogs to packers at market-determined prices based on the Midwest live hog market. Only about 5 percent of the hogs produced in the U.S. are actually owned by packers (Rhodes). Thus, the current pricing system is still predominantly in the Midwest with the rest of the U.S. deriving prices by formula from the Midwest market (Kenyon, McKissick, and Lawrence). The ongoing transition from live to carcass-based pricing has not changed the continuing tendency to use Midwest prices in formula arrangements between producer and packer.

Smaller producers (<10,000 head) are very concerned about market access and fair and open pricing. Some packers have a large percentage of their kill capacity committed to a relatively small number of larger producers. For example, the new Smithfield plant in North Carolina obtains 80 percent of its hogs from five producers (*Feedstuffs*, 5/23/95). Smaller producers are concerned that they may lose access to markets as the system continues to become more coordinated through marketing supply contracts. These concerns were apparent during the period of overproduction in the fall of 1994 when the smaller producers sometimes had difficulty finding a market for their hogs, and market access became a huge problem for small producers during the price debacle of late 1998. Packers were committed to their larger producers under market supply contracts and had little capacity to buy smaller lots of non-contract hogs, especially during 1998 when production surged to record levels and slaughter levels routinely exceeded 2 million head per week.

The second feature of market supply contracts that disturbs small producers is the undisclosed premium paid producers with market supply contracts. Producers believe that hogs of equal quality should be paid equal prices. But hogs of equal quality are of greater value to packers when purchased in large lots on a consistent basis. Since the market supply contract premiums are not public knowledge, smaller producers believe they are being discriminated against. These concerns relating to market access and price premiums have led Iowa pork producers to call for more complete reporting of quantities and transaction prices paid by packers under market supply contracts (*Feedstuffs*, 2/1/93). In early 1997, the USDA investigated the pricing and procurement methods, procurement areas, and contractual agreements of 11 major hog slaughter plants in Iowa-Southern Minnesota.

In all of the discussion about vertical integration, contracting, coordination, market supply, and price window contracts, it is important to realize that most large specialized hog operations still bear the risk of low hog prices. Vertical integration and price window contracts may have shielded up to 10 percent of production from some of the vagaries of the hog price cycle. But the remaining 90 percent are still exposed to price variability.

Although production variation is declining slowly over time, the hog price cycle will continue to exist in the near future. Over the next 5-10 years, the large specialized hog producers will need to be very concerned about managing their exposure to market risks. The 1996 farm bill is expected to continue to increase farm level price variability in grains and soybeans, so specialized producers may be entering a period of increased input price risk. Large producers' demand for risk management instruments such as futures contracts may increase in the near term.

The alternative approach to risk management is to vertically integrate and coordinate, the approach that Smithfield Foods, Inc. has chosen. They developed their own production facilities (Browns), arranged joint ownership with other large producers (Carrolls' of Virginia and Circle Four), and purchased seedstock. Other large producers/packers like Premium Standard Farms and Seaboard Farms may choose to use similar approaches and spread risk across their entire production/packing/processing system. Farmland Industries has developed a coordinated system of seedstock, farrowing, and finishing using various cooperative arrangements. But as long as the mega producers (500,000 or more hogs per year) and very large producers (100,000 or more hogs per year) remain independent from packers, there are likely to be very large swings in hog prices. How the industry manages and shares these risks across the next 10 years will in large part determine the nature of the price discovery system of the future.

The location of hog production is continuing to change. Production has grown rapidly in North Carolina and declined in the Midwest. But hog numbers are increasing in some nontraditional areas like Oklahoma, Colorado, Utah, and Wyoming (Table 5). These new large complexes are primarily being built by large producers, not packers, although packers are often part of these systems. These new investments by large producers would argue that the industrialization process in the swine industry is continuing to be driven primarily by potential profits from production. The industry is relocating in non-traditional areas because of environmental concerns in more densely populated areas and because of opposition to expansion by current producers and rural residents in the more traditional production areas. The continuing relocation of production will also have implications for hog pricing systems in the future.

Swine complexes including production and packing plants in non-traditional areas are not likely to develop traditional cash markets. In these swine complexes, the producers own the packing plant or the packing plant is an integral part of the system. In some new swine areas, only 3-5 producers supply all the hogs. It is unlikely that hogs from traditional areas will move and be slaughtered in these new production areas. Over time, the relocation of the swine industry will put pressure on the current price discovery system based in the Midwest. Some of these new complexes may decide to tie their prices to retail pork prices which are about 50 percent less variable than wholesale and farm prices. With reduced price variability, they could potentially experience less variation in production and improved coordination between production and packing that would stabilize and possibly increase profits for the swine complex.

But there is a new trend developing that may give the Midwest-based cash hog market new life. Several of the mega producers have started raising feeder pigs in the Southeast and shipping them to the Midwest to be finished. Finishing hogs in the Midwest compared to the Southeast has two large advantages. Corn is 35-50 cents per bushel cheaper, and market hog prices are \$1-2 cwt higher compared to the Southeast (Kenyon Earles, and Beckman; Kenyon, McKissick, and Lawrence). Hence, finishing hogs in the Midwest can be potentially \$5-8 a head more profitable than in the Southeast. But Midwest producers and communities will have to decide if they want these large producers and their finishing operations. To date, many Midwest states have made it difficult for these large producers to operate in their states. These states need to consider the long-run economic ramifications of declining pork production if they continue to exclude large producers.

Table 5. Reported Expansion of Hog Production: 1992-1996*

Date	Company	Location	No. of Sows
4/13/92	National Farms	West Texas	20,000
4/13/92	Tyson Foods	Oklahoma	30,000
4/20/92	Murphy Farms	South West Missouri	15,000
8/31/92	National Farms	Dalhart, Colorado	20,000
8/31/92	Cimarron Pork	Oklahoma	20,000
10/12/92	Wyoming Lean Pork	Wheatland, Wyoming	20,000
10/16/92	Smithfield Foods	Milford, Utah	100,000
2/8/93	Lattimore	Northern Colorado	20,000
8/2/93	Seaboard Corp.	Guyman, Oklahoma	200,000
10/4/93	Continental Grain	Northern Missouri	20,000
2/27/95	Midwest Farms	Eastern Colorado	10,000
3/18/95	Murphy Farms	Clinton, Missouri	17,400
7/24/95	Hitch Pork Producers	Guyman, Oklahoma	20,000
9/25/95	Itoham	Wyoming	20,000
10/16/95	Seaboard Corp.	Southwestern Kansas	100,000
10/23/95	Midwest Lean Pork	Kit Carson Co., Colorado	20,000
12/18/95	Nippan Meat Packers	Pennytown, Texas	28,000
1/8/96	Premium Standard Farms	Northern Missouri	100,000
5/13/96	Prestage Farms	Mississippi & Alabama	20,000
6/17/96	Murphy Farms	Harper Co., Oklahoma	20,000
10/21/96	Pennsylvania Family Farms	Northern Pennsylvania	30,000
10/21/96	Murphy Farms	Oklahoma	43,000
Total			893,400

* Reported in *Feedstuffs* magazine. Some of these plans have been altered by problems with environmental permits, water permits, zoning ordinances, and anti-corporate laws.

Sensitivity to changing consumer tastes and preferences will play a more important role in the pricing structure of the swine industry in the future. A number of the large packers are very tuned into consumer desires, especially in the export market. These packers are going to continue to seek pricing arrangements that make it possible for them to source hogs that fit their product marketing and merchandising strategies. Several changes are imminent. Hatfield Packing Company has been experimenting with the AUTOFOM system since 1994 and began paying producers based on AUTOFOM measurements in 1997 (Bell). The system measures the ham, loin eye, belly, and shoulder cuts with 90 percent or better accuracy. The improved accuracy of the component pricing system will allow Hatfield to send even stronger price signals to producers, and better serve their consumer markets. They could eventually choose to untie their prices from Midwest live market prices, and pay producers based on wholesale prices of primal cuts.

The continued rapid growth of large producers, the decentralization of production, the need for improved market risk management, and the rapidly emerging desire to better respond to consumer desires are likely to continue to move the pork industry toward concentration and coordination. These trends will eventually move the price discovery process from the live hog cash market to the carcass market. Carcass value pricing systems are currently tied to live hog prices. Integrated swine complexes developing outside the traditional production regions do not need live hog market prices. As large mega producers and packers deal more and more in the carcass market as part of their daily business practices, the importance of a live cash market price will decline. The futures market has already moved to a carcass price market. Eventually, prices will be determined primarily at

the carcass level by the large producers and packers that have the most accurate information about supply, processing costs, and consumer demand.

According to the RMM model, the desire to improve coordination among the stages in the marketing chain will have a tendency to move control of product flows in the system closer to the final consumer during the fourth stage of structural change. As consumer desires change, those who best understand these changes can use this information to respond quickly and develop products that consumers want. Packers and processors have regular contact with retailers, restaurant chains, and institutional buyers. As these buyers needs and desires change, the processing sector is in the best position to coordinate changing consumer patterns with input supply. The major question becomes one of how will the processing sector choose to communicate consumer desires to producers? Will they use traditional cash markets, or will they seek new and largely non-price forms of coordination?

The evidence so far seems to indicate that processors will seek coordination methods beyond markets to improve the correspondence between input supply quantity and quality and consumer demand. Although marketing supply contracts and carcass value pricing have improved coordination based primarily on cash market prices, consumers are demanding many more quality and product attributes than the cash market system can adequately communicate. Currently, the market cannot communicate tenderness, color, seamfat, texture, etc. via price or price signals. To date, these attributes can only be managed by specification of genetics, production management, and nutrient management in production. These dimensions of quality must be coordinated via direct involvement in production through vertical integration, contracting, coordination, cooperative effort, or some combination of these arrangements. When the new consumer issues of food safety, animal rights, and environmental concerns are considered, it is hard to understand how these “values” can be transmitted from consumer to producer via the traditional cash market. To assure these “values” to consumers requires coordination through all phases of the system, starting with production. In Europe, these new values are leading to product differentiation based on changed and changing production and processing practices (Ouden *et al.*). To guarantee those values to consumers requires coordination of all levels in the system, something that is extremely difficult to accomplish in a marketing chain with 3-5 separate profit centers.

The swine industry is changing rapidly and is still currently concentrating on cost competition. The emphasis will likely shift in future years to increasing perceived value through product differentiation strategies (Ouden *et al.*). Expansion into the export market will require conformity to tastes and preferences of consumers in other countries including food safety and animal rights. These requirements will put additional pressure on the packing sector to coordinate consumer desires and production and processing practices. These desires will in most cases be coordinated via contracts, cooperatives, vertical integration, and other coordination devices, diverting larger and larger quantities of hogs away from the traditional cash hog market.

Over time, the current cash market system will come under extreme pressure. Swine complexes developed outside traditional Midwest markets will not need or use the Midwest cash market. Packers will continue to use more marketing supply contracts to control product flow and quality. And as consumers demand improved product quality and guarantees concerning food safety, humane treatment of animals, and protection of the environment, packers will be forced to manage input supply at the production level. All these trends argue for a declining role for cash markets and an expansion of non-market coordination among all the links in the swine marketing chain.

These market forces seem to indicate that the percentage of hogs priced on a live basis will continue to decline rapidly. Since many of the quality attributes of concern to consumers will eventually be measurable at the carcass level, the price discovery system is likely to move to the carcass level. The continued growth of swine complexes outside traditional areas and concentration in processing mean that a few large players will determine price at carcass level. Cash live prices will become a residual calculation.

Implications to the Individual Producer

What does this mean for the agribusiness community in general and the independent producer in particular? The demand for hog assembly and pricing services at country buying points will continue to decline. Most hogs will be priced as carcasses at the packer level. Those producers who are willing to produce the type of hogs packers want using prescribed production practices under some kind of contractual arrangement (not necessarily a complete production contract) will have a future in the industry. Large producers who do not enter into production contracts with packers will need to invest more time and resources in price and financial risk management, potentially generating new business opportunities in this area. Packers who are coordinated or integrated with producers will have the opportunity to expand volume by designing products for certain market segments, both domestically and internationally. As these firms gather information and improve coordination all along the marketing chain, they should be able to increase total system profits. Producers and packers who remain outside these coordinated systems will not have access to this information and will find it increasingly difficult to compete with the industrialized pork system.

The transition from the cash market to the carcass market price discovery system will be completed in the presence of much debate, research, and controversy. Smaller producers will argue that industrialized swine production will be another step in the direction of rural community decline, not to mention the environmental and odor problems associated with large production units. Much research will be conducted on the tradeoffs between increased efficiency of large production units versus the environmental and odor issues associated with them. States that choose to limit the size of production units will experience declining production. Eventually, the processing sector will move closer to the new source of hogs in non-traditional production areas, resulting in a still further decline in remaining cash markets and in the employment base in rural communities. But as the structural change occurs, the ultimate beneficiary will be consumers. They will get a higher quality product in line with their consumer desires, and most likely at a lower price.

It is the traditional independent hog producer that will face many challenges and adjustments, and who will need to carefully consider the costs and benefits of remaining an independent producer. As the industry continues to industrialize, most small producers will need to participate in the process by networking or cooperating with other producers or with packers. If they do not, they will face the very serious possibility of being excluded from the new swine production/processing system. If they are excluded, there will be changes in the rural farm communities in which they live, changes that family-farm advocates will not approve. All this needs to be brought into the dialogue about policy and market regulation as strong economic forces push the swine sector toward large size at all levels and toward integration and contract-based coordination. The costs and benefits, and how those costs and/or benefits are distributed, might prove to be an important research agenda as we move toward 2000 and beyond.

References

- Bailey, D. "Hog Heaven," *Business North Carolina*, April 1994.
- Bell, Alan. "Autofom Offers New Dimension to Carcass Measures," *Pork97*, September 1997.
- Boehlje, M. and L. Schrader. *The Industrialization of the Food System: Questions of Coordination*, paper presented to the Conference on Vertical Coordination in the Food System, June 5, 1995, Washington, D.C.
- Barkema, A. and M. Cook. "The Changing U.S. Pork Industry: A New Dilemma for Public Policy," *Economic Review*, Vol. 78, 1993.
- Brumm, M. "Hog Market Prices Called Important, But Asset Management Determines Profit," *Feedstuffs*, June 29, 1994.
- Clanton, C. "Hog Price Hot Spot." *National Hog Farmer*, August 15, 1992, pp. 18-27.
- Grimes, G. and J. Rhodes. *Hog Production and Marketing Activities of Medium and Very Large U.S. Hog Producers, 1994*, Ag. Economics Report 1995-5, University of Missouri, 1995.
- Hurt, C. "Industrialization in the Pork Industry," *Choices*, Fourth Quarter, 1994.
- Hayenga, M., V. Rhodes, G. Grimes, and J. Lawrence. *Vertical Coordination in Hog Production*, USDA, Grain Inspection, Packers and Stockyards Administration, GIPSA-RR-96-5, May 1996.
- Ikerd, J. and J. Higgins. *Some Economic Aspects of Vertical Integration in the North Carolina Hog Industry*, Department of Economics, University of North Carolina, EIR No. 31, June 1973.
- Karlson, N. and V. Eidman. *Structural Changes in Meat Packing and Processing: The Pork Sector*, Department of Agricultural and Applied Economics, University of Minnesota, SP91-31, July 1991.
- Kenyon, D. and J. Clay. "Analysis of Profit Margin Hedging Strategies for Hog Producers," *The Journal of Futures Markets*, Vol. 7, No. 2, 1987.
- Kenyon, D., T. Earles, and C. Beckman. *Virginia Versus Midwest Hog Prices*, Department of Agricultural and Applied Economics, Virginia Tech, SP-94-19, August 1994.
- Kenyon, D., J. McKissick, and J. Lawrence. "Carcass Value Pricing Systems of Hog Packers," *1996 Pork Industry Economic Review*, NPPC, March 1996.
- Kenyon, D. and K. Mundy. *Structural Change in the Hog Industry of Maryland, North Carolina, Pennsylvania, and Virginia*, Department of Agricultural Economics, Virginia Tech, 1984.
- Kenyon, D. and S. Thornsby. *Guide to Economic Opportunities in the Virginia Swine Industry*, Virginia Cooperative Extension, Pub. 448-013, 1992.
- Lawrence, J. "Factors That Influence Prices Producers Receive for Hogs: Statistical Analysis of Carcass Data Sheet and Survey Data," *1996 Pork Industry Economic Review*, NPPC, March 1996.

- Miguell, R. and L. Jones, *Vertical Coordination in Agriculture*, USDA, ERS, AER19, Washington, D.C., 1963.
- National Pork Producers Council. *Pork Chain Quality Audit*, Progress Report, April 6, 1994.
- North Carolina State University, *1979-1990 Production and Financial Summaries*, Agriculture Extension Service, Upper Coastal Plain Research Center, Rocky Mount, North Carolina, yearly issues.
- Oudern, M., A. Dijkhuizen, R. Huirne, and P. Zuurbier. "Vertical Coordination in Agricultural Production--Marketing Chains, With Special Reference to Product Differentiation in Pork," *Agribusiness*, Vol. 12, No. 3, 1996.
- Reimund, D., J. Martin, and C. Moore. *Structural Change in Agriculture: The Experience for Broilers, Fed Cattle, and Processing Vegetables*, USDA, ERS, TB No. 1648, April 1981.
- Rhodes, V. "The Industrialization of Hog Production," *Rev. of Agr. Econ.*, Vol. 17, No. 2, May 1995.
- Rhodes, V. and G. Grimes. *Large Volume Hog Production in the U.S.: A 1975 Survey*, Agricultural Experiment Station, University of Missouri, SR 114, December 1975.
- Rhodes, V., C. Stemme, and G. Grimes. *Large and Medium Volume Hog Producers: A National Survey*, Agricultural Experiment Station SR 223, University of Missouri-Columbia, February 1979.
- Schroeder, T. "An Evaluation of Hog Carcass Merit Pricing Systems," *Agribusiness*, Vol. 9, No. 4, 1993.
- Van Arsdall, R. and K. E. Nelson. *U.S. Hog Industry*, ERS, USDA, AER No. 511, June 1984.
- Van Arsdall, R. N. *Structural Characteristics of the U.S. Hog Production Industry*, USDA, ESCS, AER No. 415, Washington, D.C., December 1978.