Quality Differences and Risk Shifting Associated with Alternative Marketing Arrangements in the Swine Industry

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We analyze quality differences in market hogs across alternative procurement methods. The test results show that alternative marketing (procurement) channels generate hogs of statistically different quality. However, the quality ordering of alternative marketing arrangements is not unique, but varies across quality attributes, and the quality differences do not appear to be economically significant. We examine the relationship between alternative procurement methods for live hogs and the quality of the resulting pork products. The correlation coefficient between the non-spot market purchases of live hogs and the Hicks' composite quality index for pork products is positive and significant, but the magnitude of that effect is small. Finally, we show that different types of marketing arrangements exhibit different price volatilities, subjecting the producers selling their hogs through these channels to different levels of risk.

The transactions between producers and packers in the swine industry occur in cash or spot markets or through different types of alternative marketing arrangements (AMAs). Alternative marketing arrangements refer to all possible alternatives to the spot market and include arrangements such as procurement or marketing contracts, production contracts, and packer-owned production. The issues of farm-level price formation in the swine sector are capturing the attention of regulators and policy makers due to the declining importance of spot markets relative to the alternative marketing arrangements. A recently completed survey of hog producers and packers (Vukina et al. 2007) shows that in the 2004/2005 period only 24 percent of the market hogs were transacted through the spot/cash markets. As a comparison, in 1999, this share was 36 percent (Grimes, Plain, and Meyer 2003).

Despite many theoretically and empirically unresolved issues about the impact of alternative marketing arrangements on price formation and discovery in the hogs and cattle markets, the pressure on both federal and state legislatures to regulate all or some forms of packer ownership of livestock is mounting. As recently as Fall 2007, the Senate Agriculture Committee passed an amendment to its version of the 2007 Farm Bill that would prohibit packers from owning livestock for more than 14 days before slaughter. Under the proposed amendment to the Packers and Stockyards Act, packers could not, "own or feed livestock directly, through a subsidiary, or through an arrangement that gives the packer operational, managerial, or supervisory control over the livestock, or over the farming operation that produces the livestock."[1]

The motivations for using alternative marketing arrangments differ substantially between buyers (pork packers) and sellers (hog farmers). The use of alternative marketing arrangements by packers is usually explained in the context of various theories of the firm (see e.g. Gibbons, 2005). The fundamental economic questions of interest in this literature are: What alternatives does the firm have for organizing its activities? Why does it rely on independent suppliers for some services and on its own divisions for others? What determines which services are (or should be) purchased from outside suppliers and which should the firm provide for itself? Therefore, any theory of the firm must explain integration (i.e., whether a given transaction occurs within one firm or on the market) and should be able to predict integration for some transactions and non-integration for others (i.e., what trade-offs exist between integration and non-integration).

When it comes to vertical organization of food-supply chains, especially in livestock production, the literature mainly follows the transaction-cost

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[1]The full text of the "en bloc amendment" can be found on the Senate Agriculture Committee Web site, http://www.agriculture.senate.gov/.

paradigm. The transaction-cost or rent-seeking theory of the firm adopted the definition of integration as the unification of control rights, with the key variables characterizing the situation under which transactions take place being the degree of asset specificity and the amount of uncertainty in the market (Coase 1937; Williamson 1985). For example, den Ouden et al. (1996) identify growing quality and credence attributes requirements by consumers (such as animal welfare, food safety, traceability, and environmental stewardship) as major driving forces for more contracts and vertical integration. Similarly, some export markets also require very specific product attributes. The Japanese pork market, for instance, is famous for its specific consumer demands concerning taste, marbling, and cutting (Makise 2002). Since vertically disintegrated chains do not provide the required quality and are slow to adapt to new demands, the Japanese market has been mainly served by contractually bound or vertically integrated pork producers from Denmark or the United States. According to Hobbs, Fearne, and Spriggs (2002), various food crises such as mad cow disease are another reason for quality uncertainty becoming the major concern in agribusiness. Generally speaking, information externalities arising from uncertainties in detecting food quality may be reasons why vertical coordination is used to circumvent the marketplace (Hennesy 1996). Organizing the information flow along the supply chain for transmitting the changing customer demands to the farm stages is considered more transaction-cost efficient under contracts and in vertically integrated systems than in the spot markets.

The motivations and incentives of farmers to engage in alternative marketing arrangements have also been studied by agricultural economists (for a recent survey see Schulze, Spiller, and Theuvsen 2006). The majority of research in this area argues that contracts are a highly preferable option for farmers to reduce their risk exposure. For example, Johnson and Foster (1994) found that risk-neutral hog producers would prefer independent production and risk-averse producers would prefer to choose among various types contracts. Similarly, Pennings and Smidts (2000) found that the degree of risk aversion is important in explaining owner-managers' choices between relatively safe fixed-price contracts versus spot-market transactions in the swine industry. Using sharecropping contracts, Ackerberg and Botticini (2002) showed that if one controls for the endogenous matching between principals (landlords) and agents (tenants), the agent's risk aversion appears to significantly influence the contract choice.

This paper focuses on quality considerations as the major driver for the use of alternative marketing arrangements by pork packers and risk management as the major driver for their use by hog farmers. We hypothesize that if the packers introduced various alternative marketing arrangements with the objective to procure high-quality hogs, we should be able to detect significant difference between hogs procured through them relative to hogs procured through the spot market. Also, if the farmers' main motivation for the use of alternative marketing arrangements is risk mitigation, assuming that farmers correctly self-select themselves into contracts that correspond to their risk-aversion types, we should find that different alternative marketing arrangements provide different levels of price insurance (risk protection) as measured by the volatility of their income streams.

The results show that alternative marketing (procurement) channels generate hogs of statistically different quality. However, the quality ordering of alternative marketing arrangements is not unique, but varies across quality attributes, and the quality differences do not appear to be economically significant. Also, the relationship between the higher-order (non-spot) procurement methods for live hogs intended for slaughter and the quality of obtained pork products is positive, but the magnitude of this correlation coefficient is rather small. Finally, the results confirm our conjecture that the magnitude of risk that hog producers are exposed to varies with the marketing arrangements through which hogs are transacted.

Reasons for Using Alternative Marketing Arrangements by Hog Producers and Pork Packers

As a part of the congressionally mandated Livestock and Meat Marketing Study (see Vukina et al. 2007) a recently completed survey of buyers and sellers of live hogs indicated a number of different economic incentives associated with using alternative marketing arrangements or the cash market (see Cates et al. 2007). Among hog producers who responded

to the survey, the three most important reasons for selling their hogs using the cash markets are: independence—complete control and flexibility of own business (80 percent of respondents); ability to benefit from favorable market conditions (41 percent); and ability to sell hogs at higher prices (35 percent). For the same group, the three most important reasons for using the alternative marketing arrangements to sell hogs are: the reduction in risk exposure (76 percent of respondents); the reduction in price variability (44 percent); and improvement in securing a buyer (39 percent).

For packers responding to the survey who only use cash or spot markets for procuring market hogs, the three most important reasons for doing so are: independence—complete control and flexibility (60 percent); the ability to purchase hogs at lower prices (37 percent); and the ability to secure higher-quality hogs (36 percent). For packers responding to the survey who use alternative marketing arrangements for procuring market hogs, the three most important reasons for doing so are: improvement in week-to-week supply management (62 percent); ability to secure higher-quality market hogs (60 percent); and ability to allow better market access (40 percent).

These results provide two interesting insights which do not precisely coincide with the hypotheses that one could derive from the existing literature on the vertical integration and contracting in the livestock industries. First, the push toward increased pork quality dictated by consumers is unlikely to produce any noticeable shift toward greater use of alternative marketing arrangements because views of different market participants about which marketing arrangement produces higher-quality hogs differ. Second, the incentives to stay independent and in full control of one's own business counteract the risk-aversion considerations, with the direction of the net effect toward greater use of alternative marketing arrangements being ambiguous and likely small. These results provide the motivation to study the quality and risk shifting issues associated with various alternative marketing arrangements in the pork industry empirically.

In order to carry out the empirical analyses we use the USDA/AMS Mandatory Price Reports (MPR) data.[2] The MPR records the transactions of National Daily Direct Hog Prior Day—Slaughtered Swine through the following categories of marketing arrangements (MAs):

- Negotiated Purchases (MA1): Cash or spot-market purchase of hogs by a packer from a producer when there is an agreement on base price and a delivery day not more than 14 days after the date on which the livestock are committed to the packer.
- Other Market Formula Purchases (MA2): Purchase of hogs by a packer in which the pricing mechanism is a formula price based on any market other than the market for hogs, pork, or pork product. This includes formula purchases where the price formula is based on one or more futures and options contracts.
- Swine or Pork Market Formula Purchases (MA3): Purchase of hogs by a packer in which the pricing mechanism is a formula price based on a market for hogs, pork, or a pork product other than any formula purchase with floor, window, or ceiling price, or a futures options contract for hogs, pork, or pork product.
- Other Purchase Arrangements (MA4): Purchase of hogs by a packer that is not a negotiated purchase, hogs or pork market formula purchase, or other market formula purchase and does not involve packer-owned swine. This would include long-term contract agreements; fixed-price contracts; cost-of-production formulas; and formula purchases with a floor, window, or ceiling price.
- Packer Owned (MA5): Hogs that a packer, including a subsidiary or affiliate of the packer, owns for at least 14 days immediately before slaughter.
- Packer Sold (MA6): Hogs that are owned by a packer, including a subsidiary or affiliate of the packer, for more than 14 days immediately before sale for slaughter and are sold for slaughter to another packer.

Ranking of Alternative Marketing Arrangements by Quality Attributes

This section analyzes the differences in the quality of finished market hogs (barrows and gilts) intend-

[2] MPR is available at http://mpr.datamart.ams.usda.gov.

ed for slaughter across marketing arrangements through which they were procured. Regardless of the marketing arrangement used to procure the finished market hogs, the animals are shipped to a packer, and after being slaughtered, the carcasses are inspected for wholesomeness by USDA/FSIS or by a state government inspection system. Unlike beef, pork is rarely quality graded by USDA/AMS.[3] Instead packers rely on other measures of quality. The pork industry began using its own measurements and moved away from grades in the early 1990s. The main problem with the USDA standards was that slaughtered animals were not well-differentiated by quality, so approximately 85 percent or more of the hogs were graded as U.S. No. 1–2.

The definitions of quality indicators based on Mandatory Price Report data are as follows:

- Average lean percentage (in percent): Value equal to the average percentage of the carcass weight composing lean meat.
- Loin-eye area (in square inches): The surface area of the Longissimus dorsi muscle at the tenth rib of a pork carcass.
- Average loin depth (in inches): Average muscle depth measured between the third and fourth rib from the last rib, 7 cm from the carcass split.
- Average backfat (in inches): Average fat thickness measured between the third and fourth rib from the last rib, 7 cm from the carcass split.
- Fat-free lean index: Index measuring the final carcass fat-free lean as a percentage of the carcass. This index can be calculated and estimated from a fat probe between the third and fourth rib, 7 cm off the midline of the hot carcass. The fat-free lean index is calculated as follows: $51.537 + (0.035 \times \text{Carcass, lb}) - (12.260 \times \text{Backfat, inch})$.

The data represent daily observations for the period between August 3, 2001, and September 30, 2005. The summary statistics for five different quality attributes are reported in Table 1. The highest-quality hogs typically come from the other purchase arrangements (MA4). This is true for two out of five quality measurements: the thinnest average backfat (0.7455 inches) and the largest fat-free lean index (49.216). The second highest-quality hogs come through the other market formula purchases (MA2) that also have two highest-quality attributes: the largest loin-eye area (7.36 square in), and the thickest average loin depth (2.45 in). We ranked MA4 ahead of MA2 because MA2 is also associated with the two worst quality attributes (the thickest average backfat of 0.7675 inches and the lowest fat-free lean index of 48.947), while MA4 is never ranked last in any of the considered quality attributes. The only remaining quality attribute is the average lean percent. According to this attribute, the highest ranked AMA is the swine or pork market formula purchases (MA3) with the highest average lean percent of 54.31 percent.

Judging by the same five quality attributes, the lowest-quality hogs are recorded in the packer sold category (MA6). In three out of five quality attributes (average lean percent, loin-eye area, and average loin depth), MA6 ranked last, which seems to indicate that packers sell lower-quality hogs to other (perhaps small specialized) packers rather than slaughtering those hogs themselves.

Next, we test whether the means of a given quality attribute are statistically different across marketing arrangements. We use the paired observation procedure, which applies to samples with the same number of observations that are not independent and has variances of the two populations that are not

[3] See the official standards for swine in the Official United States Standards for the Grades of Slaughter Swine promulgated by the Secretary of Agriculture under the Agricultural Marketing Act of 1946 (60 Stat. 1087; 7U.S.C. 1621-1627), with amendments effective January 14, 1985. The USDA standards segregated swine according to intended use (slaughter or feeder), class (sex), and grade (apparent relative excellence and desirability for particular use). Grades of slaughter barrows and gilts were predicated on the same two general considerations that provided the basis for the grades of barrow and gilt carcasses: quality (which includes characteristics of the leanness and firmness of fat) and characteristics related to the combined carcass yields of the four lean cuts (ham, loin, picnic shoulder, and Boston butt). With respect to quality, two general levels were considered. Barrows and gilts with characteristics indicating that the carcass will have acceptable belly thickness and lean quality and acceptable firmness of fat receive grades U.S. No. 1–4, whereas others are graded as U.S. Utility. The grades U.S. No. 1–4 were based entirely on the combination of factors that predict the expected combined carcass yields of the mentioned four lean cuts. The official grade for slaughter barrows and gilts having acceptable quality was determined by considering two characteristics: backfat thickness over the last rib and the muscling score. Values of these factors were then used in a mathematical equation to arrive at the final grade.

Table 1. Quality Attributes by Marketing Arrangement in the Hog Industry.

		Marketing arrangement					
Quality attributes		MA1	MA2	MA3	MA4	MA5	MA6
Average lean percentage	Sample size	1,059	1,059	1,059	1,059	1,059	1,055
	Mean	53.38	53.95	54.31	54.09	53.40	53.23
	SD	0.35	0.36	0.26	0.27	0.34	1.06
	CV	0.65	0.66	0.49	0.50	0.63	1.99
Loineye area	Sample size	1,060	1,060	1,060	1,060	294	1,055
	Mean	6.73	7.36	7.33	6.79	6.66	6.52
	SD	0.12	0.23	0.12	0.15	0.09	0.36
	CV	1.80	3.15	1.68	2.22	1.37	5.47
Average loin depth	Sample size	1,060	1,060	1,060	1,060	1,058	1,055
	Mean	2.24	2.45	2.44	2.26	2.22	2.18
	SD	0.04	0.08	0.04	0.05	0.03	0.12
	CV	1.77	3.10	1.65	2.19	1.47	5.37
Average backfat	Sample size	1,060	1,060	1,060	1,060	1,058	1,055
	Mean	0.7668	0.7675	0.7474	0.7455	0.7666	0.7535
	SD	0.02	0.02	0.02	0.02	0.02	0.04
	CV	2.78	2.51	2.42	2.06	2.68	5.20
Fat-free lean index	Sample size	1,060	1,060	1,060	1,060	1,058	1,055
	Mean	48.955	48.947	49.193	49.216	48.957	49.118
	SD	0.29	0.23	0.24	0.21	0.27	0.50
	CV	0.59	0.48	0.50	0.42	0.54	1.01

SD = standard deviation
CV = coefficient of variation
MA1 = Negotiated purchases
MA2 = Other market formula
MA3 = Swine or pork market formula
MA4 = Other purchase agreements
MA5 = Packer owned
MA6 = Packer sold

necessarily equal. A $(1 - \alpha)$ 100 percent confidence interval for $\mu_D = \mu_1 - \mu_2$ for paired observations is given by

$$(1)\quad \bar{d} - t_{\frac{\alpha}{2}} \frac{s_d}{\sqrt{n}} < \mu_D < \bar{d} + t_{\frac{\alpha}{2}} \frac{s_d}{\sqrt{n}} \quad ,$$

where $\bar{d}$ and s_d are the mean and standard deviation of the normally distributed differences of n random pairs of measurements, and $t_{\alpha/2}$ is the t-value with $(n - 1)$ degrees of freedom (see Walpole and Myers 1989, p. 254).

Tables 2–6 present the rankings of the marketing arrangements by their average quality attributes. For example, Table 2 presents the ranking of marketing arrangements with respect to average lean percentage. For example, the hogs with the highest average lean percentage of 54.31 percent came from swine or pork market formula (MA3), followed by the other purchase arrangement (MA4). In the right-hand side panel of the Table, we test whether quality means are pair-wise different across alternative marketing arrangements at the five-percent confidence interval. As the results suggest, all lean percentage means are different from each other. Testing for the pair-wise differences across means produced similar results for other quality attributes. Most of the means are statistically significantly different from each other.[4]

Finally, for illustration purposes, the actual measurements of the daily fluctuations in two quality attributes of the best and the worst marketing arrangements are graphed in Figures 1 and 2. In Figure 1 the data exhibit a fairly large difference in loin

[4] The loin-eye area pairwise difference of any channel with the *packer-owned* channel is calculated based on the smaller sample because the packer-owned data have a lot of missing values for loin-eye area.

Table 2. Ranking of Marketing Arrangements by Average Lean Percent.

Average lean percent		Are means pairwise different at α = 0.05?				
(Decreasing quality rank)	Mean (%)	MA4	MA2	MA5	MA1	MA6
1. Swine/pork mkt formula (MA3)	54.31	yes	yes	yes	yes	yes
2. Other purchase arrangement (MA4)	54.09		yes	yes	yes	yes
3. Other market formula (MA2)	53.95			yes	yes	yes
4. Packer owned (MA5)	53.40				yes	yes
5. Negotiated (MA1)	53.38					yes
6. Packer sold (MA6)	53.23					

Table 3. Ranking of Marketing Arrangements by Loin-Eye Area.

Loin-eye area		Are means pairwise different at α = 0.05?				
(Decreasing quality rank)	Mean (in^2)	MA3	MA4	MA1	MA5	MA6
1. Other market formula (MA2)	7.36	yes	yes	yes	yes	yes
2. Swine/pork market formula (MA3)	7.33		yes	yes	yes	yes
3. Other purchase agreement (MA4)	6.79			yes	yes	yes
4. Negotiated (MA1)	6.73				yes	yes
5. Packer owned (MA5)	6.66					yes
6. Packer sold (MA6)	6.52					

Table 4. Ranking of Marketing Arrangements by Average Loin Depth.

Loin depth		Are means pairwise different at α = 0.05?				
(Decreasing quality rank)	Mean (in)	MA3	MA4	MA1	MA5	MA6
1. Other market formula (MA2)	2.45	yes	yes	yes	yes	yes
2. Swine/pork market formula (MA3)	2.44		yes	yes	yes	yes
3. Other purchase agreement (MA4)	2.26			yes	yes	yes
4. Negotiated (MA1)	2.24				yes	yes
5. Packer owned (MA5)	2.22					yes
6. Packer sold (MA6)	2.18					

Table 5. Ranking of Marketing Arrangements by Average Backfat.

Backfat		Are means pairwise different at α = 0.05?				
(Decreasing quality rank)	Mean (in)	MA3	MA6	MA5	MA1	MA2
1. Other purchase agreement (MA4)	0.7475	yes	yes	yes	yes	yes
2. Swine/pork market formula (MA3)	0.7474		yes	yes	yes	yes
3. Packer sold (MA6)	0.7535			yes	yes	yes
4. Packer owned (MA5)	0.7666				no	no
5. Negotiated (MA1)	0.7668					no
6. Other market formula (MA2)	0.7675					

Table 6. Ranking of Marketing Arrangements by Fat-Free Lean Index.

Fat-Free Lean Index		Are means pairwise different at α = 0.05?				
(Decreasing quality rank)	Mean (in)	MA3	MA6	MA5	MA1	MA2
1. Other purchase agreement (MA4)	49.22	yes	yes	yes	yes	yes
2. Swine/pork market formula (MA3)	49.19		yes	yes	yes	yes
3. Packer sold (MA6)	49.12			yes	yes	yes
4. Packer owned (MA5)	48.96				no	no
5. Negotiated (MA1)	48.96					no
6. Other market formula (MA2)	48.95					

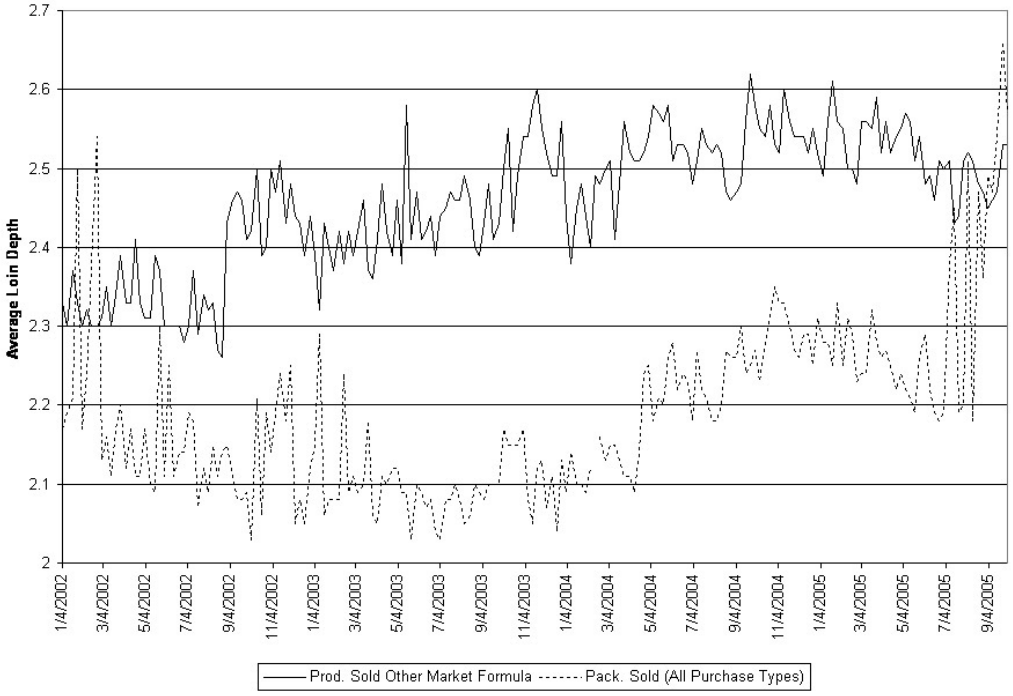

Figure 1. Average Loin Depth: January 2002–September 2005.

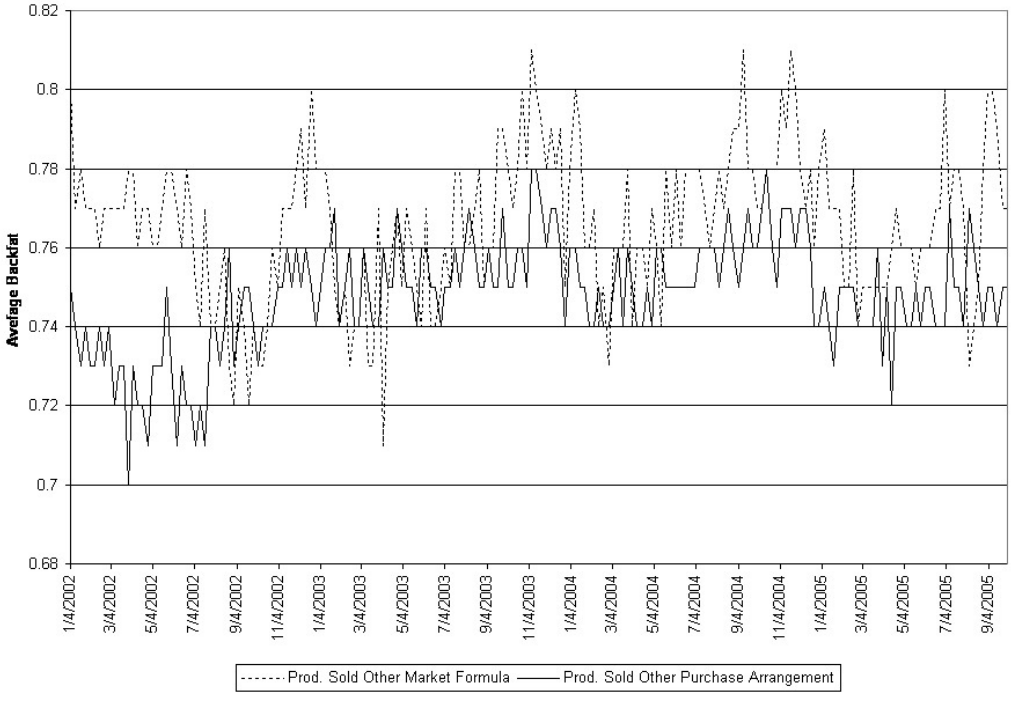

Figure 2. Average Backfat: January 2002–September 2005.

depths between the best and the worst marketing arrangement (in this case, other market formula and packer sold), whereas in Figure 2, one sees that the difference between the best and the worst marketing arrangement (in this case, other purchase arrangements and other market formula) in terms of backfat is rather small.

The economic significance of these statistically significant quality differences across alternative marketing arrangements is difficult to judge, as they appear to be quite small. One way to go about it is to look at hog-carcass merit-adjustment schedules that packers use to calculate quality premiums or discounts. In most marketing contracts, the total price that the producer will receive for his hogs is the combination of the base price (formula, cost-plus, window, or floor price) and various quality premiums. Some contractors pay high base prices and low-quality premiums; others do the opposite. Some packers prefer lighter carcasses, whereas others who specialize in boxed products may prefer heavier carcasses. In some contracts, the premiums are paid in dollars per pound; in other contracts, they are paid as a percentage of the base price. Contracts are typically specified such that the total payment to the producer is determined by adding the packer's standard quality grid to the contracted base price.

Quality grids are typically two-dimensional arrays where the bonus index is obtained by the intersection of two quality attributes: typically carcass weight and one other quality attribute, frequently average lean percent. An example of a carcass-merit matrix from the Grain Inspection, Packers and Stockyards Administration swine contract library indicates that percent lean range (between 42 percent and 60.9 percent) is given in grid increments of one percent, and the weight range (133–216 pounds carcass, which corresponds to 180–292 pounds live weight) is divided into five weight brackets. For example, for the leanest carcasses (between 60 and 60.9 percent lean) and for live weight ranging between 232 and 263 pounds (which corresponds to 172 to 195 pounds of carcass weight), the producer receives a price premium of five percent over the base price (index 105). The same weight category carcasses that are only 42 to 42.9 percent lean will receive a penalty of eight percent below the base price (index 92).

In our case, as seen from Table 2, the worst average lean percent (53.23 percent) is obtained with hogs from MA6 (packer sold) and the best (54.31 percent) from MA3 (swine or pork market formula). According to the quality grid table above, these percentages belong to different percent lean categories but for all five weight categories they would command the same premiums. In particular, for both lean percent categories (53.0–53.9 percent and 54.0–54.9 percent) the premium indexes are 88 (for 133–145 pounds carcass weight), 92 (146–160 pounds), 101 (161–171 pounds), 103 (172–195 pounds), and again 103 (196–216 pounds). Based on the presented simple analysis one can conclude that, despite the fact that they are statistically significantly different from each other, live hogs purchased through six procurement channels appear to be of materially indistinguishable quality because they would all command the exact same premiums. This result may explain the packers' ambiguity about the connection between the quality of live hogs and the increased use of the alternative marketing arrangements.

Quality Measurement Using Hicks' Composite Commodity Index

In this section, we use national Mandatory Price Report data for current volumes by purchase type (daily observations on head count, barrows, and gilts) and pork carcass cut-out (weekly observations on primal values and load counts).[5] The data have been aggregated into 50 monthly observations by calculating monthly sums of quantity variables and monthly simple averages of primal cuts values. The values of various pork cuts are deflated using the consumer price index for pork (1982–84 = 100).[6]

First, we construct the average quality index based on Hicks' composite commodity formula (Theil 1952–1953; Cramer 1973; Nelson 1991). This quality index is formulated as

$$(2)\quad V_G = \frac{\sum_{i \in G} p_i x_i}{q_G},$$

[5] These observations were obtained from various issues of USDA National Meat Trade Review (http://www.ams.usda.gov/LSMNpubs/PDFMonthly/ composite.htm).

[6] These observations were obtained from various issues of USDA National Meat Trade Review (http://www.ams.usda.gov/LSMNpubs/PDFMonthly/ composite.htm).

where x_i are the quantities of elementary goods measured in pounds (various pork cuts: loin, butt, picnic, rib, ham, belly) that belong to the same commodity group G, p_i are the wholesale prices per pound of various pork cuts, and $q_G = \sum_{i \in G} x_i$ is the heterogeneous commodity group (pork meat). Based on Equation 2, the larger the proportion of higher priced cuts in the total sales bundle, the higher the quality measure. To establish the link between pork quality and live hogs quality, we link the aggregate V_G to the composition of alternative marketing arrangements for the upstream segment. This will give us some indication of the pork quality differences caused by different combinations of upstream alternative marketing arrangements.

To implement this method, we calculated the percentage share of all marketing arrangements other than negotiated purchases (MA1) and packer sold (MA6) in the total volume of live animals purchased. The variable is constructed as the ratio between (other market formula purchases + swine/pork market formula purchases + other purchase arrangement + packer owned) and total purchases, where the total purchases contain all of the above methods plus negotiated (spot) purchases and packer sold. The prediction here is that alternative marketing arrangements should on average enable packers to acquire higher-quality hogs (and hence produce higher-quality pork) than those acquired on the cash/spot market or via the packer-sold channel.

The time plot of both series is presented in Figure 3. The percentage of alternative marketing arrangment purchases (HdCnt) exhibits a time trend, while the pork-quality index (VgDefl) does not. This

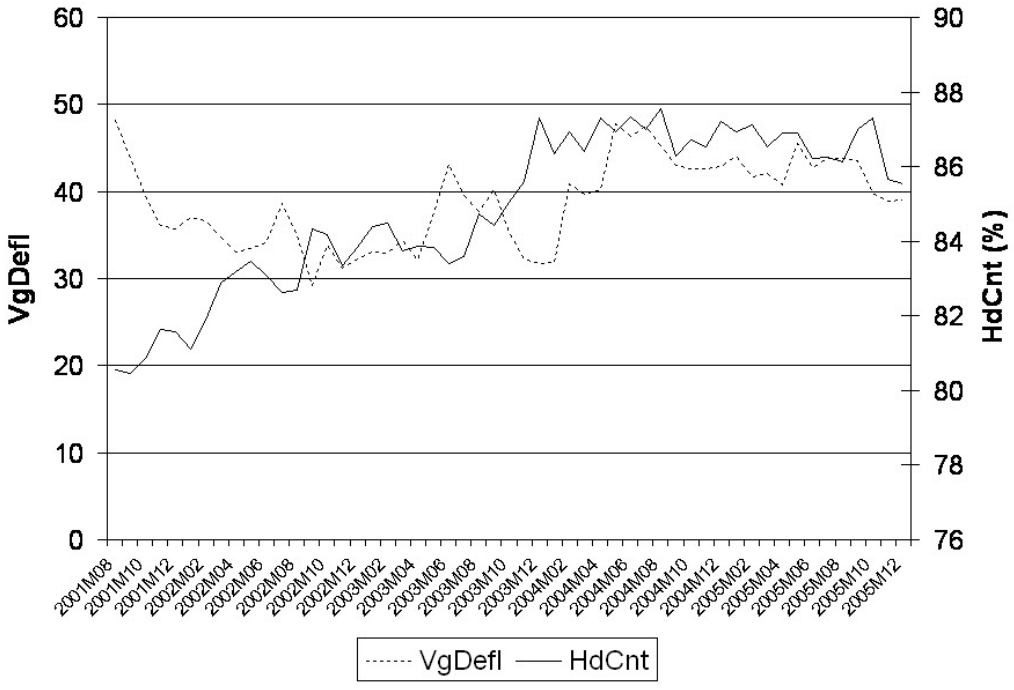

Figure 3. The Relationship between Pork Quality and the AMAs' Share in Total Hog Purchases.

VGDefl = Pork quality index using Hicks' composite commodity formula.
HdCnt = Percentage of AMA purchases (headcount).

clearly indicates that the steady increase in the use of higher-order alternative marketing arrangements in total swine procurement was not accompanied by an equal increase in pork quality. Because our purpose is to examine the qualitative relationship between the two time series, we calculated the correlation coefficient. The estimated sample correlation coefficient between the two series is 0.3661, with a 95-percent confidence interval of (0.098, 0.5849). Therefore, we reject the null hypothesis of no correlation between the pork quality and the share of alternative marketing arrangements in the total market hog purchases at the five-percent significance level.[7] Based on this result, we conclude that more hogs purchased through alternative marketing arrangements translate into higher-quality pork products, but the magnitude of that effect seems to be small. This result may also explain the packers' ambiguity about the connection between the quality of live hogs and the increased use of the alternative marketing arrangements.

Risk Shifting

The literature suggests that hog producers (and economic agents in general) will, if offered a menu of alternative marketing arrangements where each arrangement is associated with some volatility of income streams, self-select themselves correctly into the arrangements most conformable with their risk-aversion type.[8] Risk-neutral (or perhaps even risk-loving) agents would choose risky projects, whereas risk-averse agents would choose safer bets. But since agents' level of risk-aversion is not observable and also generally very difficult to measure, the available data does not allow us to stratify hog producers according to their risk-aversion attitudes, and so we cannot test whether they correctly sorted themselves into alternative marketing arrangements according to their riskiness. However, knowing that farmers risk attitudes and risk-bearing capabilities differ,[9] we anticipate seeing different alternative marketing arrangements offering different levels of risk insurance, i.e. we expect to see different volatilities of income streams associated with various alternative marketing arrangements. Measuring the difference in riskiness (volatility) of different alternative marketing arrangement income streams becomes an interesting empirical question.

Hog farmers are concerned with several types of risk. The most important among them is price risk (both on the input side as well as on the output side), followed by various types of production risks (common and idiosyncratic), and finally, market-access risk. Various types of marketing arrangements are associated with different levels of risk, and they can transfer different components of the total risk from the producer/farmer to the contractor (packer or integrator). Production contracts usually eliminate the entire price risk and the market-access risk from the responsibility of the producer. They could also eliminate the common production risk in cases where the payment to the grower is based on some relative performance scheme. Marketing contracts generally eliminate market-access risk, could sometimes eliminate some of the price risk, but would generally not eliminate production risk. Finally, cash or spot-market sales expose the producer to all types of risk associated with hog production.

The analysis of risk shifting is accomplished by measuring the variances of payments received by producers selling their hogs through different alternative marketing arrangment channels and testing whether the pairwise differences among those variances are statistically significant. Because we are interested in comparing the volatilities in the marketing contracts channels against the spot/cash market, we exclude marketing channel MA5, because it covers the packer-owned hogs, and MA6, where the origin of hogs is unknown.[10]

Assuming that the variance of the price through each arrangement over time represents the risk of

[7] The t-test statistic (2.726) is greater than the critical value (2.01).

[8] For example, Zheng, Vukina, and Shin (2007) have shown that hog farmers who use production contracts are more risk averse than are farmers who use spot markets or marketing contracts.

[9] For example, Pennings and Wansink (2004) found that 39 percent of Dutch hog producers were risk averse, four percent were risk neutral, and 57 percent risk seeking.

[10] Ideally, we would like to measure the amount of risk transferred from the producers to the integrators or packers under production contracts, but the contract settlements data is not part of the MPR database. However, in an earlier study Martin (1997) showed that production contracts eliminate about 94 percent of the total income variability to which an independent farmer selling hogs on the spot market would be exposed.

that particular arrangement, we compiled the daily average net prices of each arrangement from August 3, 2001 through March 27, 2006, and conducted a pair-wise test of equal variance. The prices are base prices for barrows and gilts, carcass basis expressed in $/cwt. Greater variance of payments indicates the higher risk (see Table 7). Based on the computed variances (main diagonal elements in Table 7), we ordered the marketing arrangements according to the magnitude of risk they carry: MA1, MA3, MA2, and MA4. This order is quite intuitive: MA1 is cash or spot-market sales, which should obviously have the greatest risk; MA3 is marketing contracts whose pricing formula is based on different spot markets; MA2 is another type of marketing arrangement whose pricing formula is based on some futures or options price; and MA4 contains ledgers, windows, and other pricing mechanisms, which all serve as a cushion against the price volatility.

The amount of risk, as measured by the variance of price, that can be eliminated by switching away from the spot market (MA1) and instead selling the hogs through one of the marketing contracts could be economically significant. For example, the variance of price obtained though MA4 channel (other purchase agreements) is only about one-third of the variance of negotiated (spot) price and quite similar to the variance of other market-formula purchases (MA2). However, the variance of price associated with the swine or pork market formula (MA3), whose contract price is determined by some spot-market price, offers hardly any insurance against price risk. The variance of MA1 is only about 10 percent higher than the variance of MA3.

To test the null hypothesis that the variances of the payments are identical under two different types of arrangements, we can use the asymptotic Wald test proposed by Knoeber and Thurman (1995). The test statistic is given by

$$(3)\quad T = \frac{s_1^2 - s_2^2}{[\frac{2}{n}(s_1^4 + s_2^2 - 2s_{12}^2)]^{1/2}},$$

where s_1^2 and s_2^2 are the sample variances for two different payment time series and s_{12} is the sample covariance. Under the null, T is asymptotically standard normal. This test is needed when the two price series are not statistically independent (otherwise, the standard F-test could be used for testing the equal variances).

For different combinations of ordered variances for i and j, the null and the alternative hypotheses are given as

$$(4)\quad \begin{aligned} H_0 &: \text{Var(price of MA}_i\text{)} = \text{Var(price of MA}_j\text{)} \\ H_1 &: \text{Var(price of MA}_i\text{)} > \text{Var(price of MA}_j\text{)}. \end{aligned}$$

The results are summarized in Table 8. The results indicate that all null hypotheses were rejected at one-percent level of significance. The pair-wise testing of the differences in prices across various marketing arrangements thus confirmed that all price variances are statistically different from each other. We therefore conclude that the magnitude of risk that hog producers are exposed to varies with the marketing arrangements through which the hogs are transacted. Aside from the production contracts, which are designed to transfer almost the entire risk associated with growing hogs from the producer to the contractor, the most insurance to producers against the price risk is provided by MA4

Table 7. Variance-Covariance Matrix of Hogs Prices by Marketing Channel.

Marketing channel	MA1	MA2	MA3	MA4
MA1	132.89	71.64	126.13	75.63
MA2		52.71	68.03	39.52
MA3			120.18	72.37
MA4				47.78

Table 8. Test for Risk Reduction: Cash Sales and AMAs.

Tests[a]	Wald test statistic	p value
MA1[b] vs. MA2[c]	19.37	0.000
MA1 vs. MA3[d]	18.42	0.000
MA1 vs. MA4[e]	22.49	0.000
MA3 vs. MA2	18.42	0.000
MA3 vs. MA4	22.31	0.000
MA2 vs. MA4	2.73	0.003

[a] Test (MA_i vs. MA_j) hypotheses are
H_0 : *Var*(price of MA_i) = *Var*(price of MA_j)
H_1 : *Var*(price of MA_i) > *Var*(price of MA_j)
[b] MA1: Negotiated purchases
[c] MA2: Other market formula
[d] MA3: Swine or pork market formula
[e] MA4: Other purchase agreements

(other purchase agreements) that contains ledgers, windows, and other pricing mechanisms, which all serve as a cushion against price volatility.

Conclusions

This article analyzes quality differences in live market hogs across alternative procurement methods. First, we tested if various quality attributes used by the industry are significantly different across marketing arrangements. Test results indicate that different marketing arrangements yield different quality hogs but the rankings are not unique but rather vary with the quality attributes. We also found that despite the fact that marketing contracts (especially other purchase arrangements and other market formula purchases) consistently yield statistically higher-quality hogs than did negotiated (spot) purchases, the quality differences do not appear to be economically significant.

Second, we examined the relationship between the proportion of the higher level procurement methods in the total acquisition of live market hogs and the quality of resulting pork products. We measured pork quality by Hicks' composite commodity index and assumed that a higher percentage share of the alternative marketing arrangements (marketing contracts and packer-owned hogs) should produce higher-quality pork products. The correlation coefficient showed that these two series are positively correlated, but the magnitude of that effect seems to be small, which may explain the packers' ambiguity about the connection between the quality of live hogs and the increased use of the alternative marketing arrangements.

Finally, we analyzed the transfer of risk from risk-averse farmers to risk-neutral (or less risk-averse) firms (integrators and packers). We were able to show that different types of marketing arrangements exhibit different price volatilities as measured by the variance of price; thus they may subject the producers selling their hogs through these channels to different levels of risk. The ordering of marketing arrangements by the risk they carry is quite intuitive: (1) cash/spot-market sales; (2) marketing contracts whose pricing formula is based on different spot markets; (3) marketing arrangements whose pricing formula is based on some futures or options price; and (4) other purchase arrangements containing ledgers, windows, etc., and all variances are statistically significantly different from each other. However, the magnitude of the actual risk reduction for some alternative marketing arrangements (for example MA3) is not very large, indicating that other aspects of business risk, such as market access risk, may be dominating price-risk

consideration for many farmers.

All of the above results seem to be casting some doubts into the standard explanations for why we observe contracts and other forms of vertical coordination in the livestock-production and meat-packing industries. First, when it comes to packers' motivations for using alternative marketing arrangements, the quality-control considerations seem to be overplayed. This conclusion follows from the analysis of packers' own responses to survey questions as well as from the statistical analysis of quality differences of live hogs purchased through different channels. Further research into this very interesting topic is critically needed. Second, when it comes to producers' motivations, the risk-management rationale, albeit important, seems to require different interpretation. It is probably not the price risk *per se* that motivates producers to use contracts; the security of market access and timing could be something they worry more about.

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