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FORMULA MARKET CONTRACTS IN THE SWINE INDUSTRY

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Abstract

One aspect of increasing market channel coordination in the swine industry is the offering of long-term market contracts by pork processors to swine producers. This paper seeks to examine the existing contracts and develop a theoretical framework for analyzing jointly optimal levels of contracting.

Formula Market Contracts in the Swine Industry

Several authors have provided descriptive overviews of the structural changes occuring in the swine industry (Rhodes, Hurt, Boehlje). One such structural change is the trend towards increased integration by some of the larger pork producers. Another change is the recent introduction of long-term marketing agreements/contracts by several pork processors. A common theme in these studies is that the trend towards vertical integration and increased contracting is a result of efforts by pork producers and processors to develop more efficient marketing/production institutions. Processors and producers are also seeking ways to reduce the risks surrounding supply quantity and quality assurance (particularly when attributes are difficult to identify) and price assurance.

A recent study by Hayenga et al. reports results of a survey investigating the extent of vertical coordination between packers and hog producers. The results suggest that in 1994 the 20 largest packers procured 11 percent of their hogs through long-term (defined as 6 months or longer) contracts. Typically these long-term contracts require that the independent hog producer deliver a preestablished quantity of hogs satisfying specific quality characteristics by specific dates. Packers reported that the primary advantages of long-term contracting were improved input quality, and improvements in the quantity and consistency of hogs brought into the plant. The only disadvantages reported in the study were "increased price risk and reduced flexibility" by offering the contracts. This disadvantage is likely a result of the packers' view that they operate in a competitive market and that the downside of contracts is that they may be placed in unfavorable trade positions if the market moves unfavorably[1]. In a similar survey of large hog producers, Hayenga et al. reported that producers viewed the major benefits of contracting were; market assurance, reduced price risk, better prices and reduced transactions costs. Hog producers thought the major disadvantages of contracting were "reduced flexibility" and "lower returns".

In their study, Hayenga et al. estimate that by 1998 the largest packers will use contracts to procure about 25 percent of their slaughter hogs. However, although their report documents the extent of long-term contracts, it provides neither theoretical nor empirical evidence to support the conclusions drawn from their survey regarding actual price risk implications. This is especially true for the inferences pertaining to survey participants' perceptions of price risk levels and the distribution/sharing of price risk between producers and packers. Also, the study does not provide any justification of the estimate of future contracting levels in the industry. However, a few other attempts have been made to model production contract behavior in the swine industry (Johnson and Foster; and Martin). Knoeber and Thurman recently described production contract behavior in the broiler industry, and a study conceptually related to ours is that of Buccola and French, who evaluated several alternative vegetable marketing contracts.

In general, these previous studies have sought to quantify the risk shifting properties of the contracts themselves. Given that the swine industry is moving from an industrial structure that was primarily a competitive commodity market system to one that uses both markets and other coordination devices, we are more concerned with the market level implications associated with contracts and in determining optimal contract levels and how price risk affects this outcome. Hence, this paper lays out a framework within which one can theoretically analyze (and empirically test for) the effects that market and contract price risks and price levels might have on contracting levels. The model we present captures the salient features of the contractual relationship between a single representative packer and single representative producer when both are concerned with price risk. The contracting parameters are based on actual contracts obtained from pork packers actively engaged in long-term market agreements. The theoretical framework will allow for empirical testing of optimal contracting provisions based on readily available price and quantity data.

Representative Long-Term Marketing Agreements

Two representative long-term market agreements were obtained from Midwestern meat packers. Both contracts were originally offered in 1994. The contracts are proprietary and, hence, the packers' names are withheld. The first contract, termed a “price window” contract, offers a 5-7 year hog delivery commitment and establishes upper and lower price bounds (a price window) to value the hogs exchanged. If the market price falls within the "price window" then the packer and producer exchange the hogs for the market price. If the market price falls outside the price window, the packer and producer split the difference between the nearest bound and the market price. For this particular contract the producer must deliver to the packer all of the hogs it produces during the life of the contract. This clause keeps the producer from searching for better price alternatives and removes incentives for sorting hogs to meet the minimum quality specifications of the contract.

The second contract uses a formula price mechanism (also referred to as a cost plus contract) to establish a guaranteed minimum price. The formula price is composed of (i) an amount based on key input prices such as corn and soybean meal and (ii) a fixed margin. With the formula price, hog prices are linked to input prices and producers are ensured a margin above the costs of production. If the market price is below the guaranteed minimum price, the producer is paid the guaranteed minimum price. If the market price is above the guaranteed minimum price, the producer and the packer split the difference between the guaranteed minimum price and the market price.

Both contracts have several negotiable clauses regarding the time of delivery, renegotiation conditions, minimum quality standards, and payment criteria. Also an implicit assumption underlying the contract is that the long run market hog price will be near the long run contract price and hence, neither party makes windfall profits through the contract. To maintain this condition, repayment clauses are employed where the party with windfall profits relative to the live hog market repays the excess profits to the losing party.

As a backdrop for developing a theoretical model of contracting levels and price risk management, we analyzed the historical behavior of the above contracts. To do this we simply used the formulas defined by the contracts and calculated the contract prices which would have been paid. We simulated both formula price contracts and price window contracts. Actual market price data was used to simulate how each contract would have performed, on a weekly basis, from 1984 through 1994.

In the price window simulation the minimum price bound is $38/cwt. and the upper price bound is $48/cwt. Any price within this interval was the price the hogs were exchanged for. If the market price fell outside the interval, the packer and the producer split the difference between the nearest end of the price range and the actual market price.

The assumptions for the price formula contract simulation are explicitly specified in an extensive corn/soymeal price matrix. However, the basic premise is that a hog base price is determined by a formula including corn and soymeal prices. A premium of $5/cwt. is added to this base price. If the base price plus premium is above the market price, that is the price paid. If the based price plus premium is below the market price, the packer and the producer split the difference between the two prices. Summary results for both contracts are shown in Table 1.

TABLE 1. LONG-TERM MARKET CONTRACT PRICE PERFORMANCE VS. CASH PRICES, 1984-94[a]

	Cash Market	Price Window	Price Formula
Average Price	$47.28	$46.26	$45.56
Standard Error	$6.33	$4.77	$2.94
Effective Support[b]	not relevant	5%	28%
Average Price Gain[c]	not relevant	$1.85	$1.08
Effective Ceiling[d]	not relevant	43%	72%
Average Price Loss[e]	not relevant	$2.62	$2.77

[a] Performance comparisons are subject to assumptions in text. This table is meant only as a sample of key variables useful in comparing contracts.
[b] Percent of time the contract supported the price above the market price.
[c] Average price gained during periods the contract acted as a price support.
[d] Percent of time contract capped the price below the market price.
[e] Average price foregone during periods the contract acted as a price ceiling.

Two important points emerge from this analysis. First, the average values and standard errors of prices under either contract are lower than the market price. Second, both contracts would have acted as an effective price ceiling more often than as an effective price support, and the value foregone by the producer is much larger than the value gained. These two points suggest that producers might be paying a risk premium in order to shift some of the price risk to processors. Further, while we can reasonably expect prices to behave in the next ten years similarly to the way they've behaved in the past ten years, that is not necessarily the case. Changes in the average level or changes in price fluctuations can significantly affect the value of these contracts.

Given that these contracts are being offered, one of the questions often asked is "how much of their total slaughter will packers forward contract in long-term agreements?" This question is relevant to packers because they recognize that the greater the fixity of their procurement and prices due to contracts, the greater is their exposure to market quantity and price fluctuations. It is relevant to producers because if the incentives are great enough packers may seek to contract all their hog production and producers not holding contracts would be left without a market. To date, there have been no formulations that would prove useful in predicting the optimal level of market contracts as a function of observed price volatility. The remainder of this paper develops a theoretical framework for calculating the optimal contracting level given observed price levels and price variability. As indicated by Hayenga et al., packers may have incentives to contract for quality control as well. However, introducing quality variation into the model significantly complicates it. Furthermore, while data is readily available to assess the issue of price risk, little information is available on actual quality variation in hogs over time. However, if the theoretical and empirical tests of price risk as an incentive for contracting are insufficient for explaining the level of contracting actually observed in the market, it is likely that the remaining incentive might be linked to the quality variation issue.

Theoretical Model to Determine Optimal Market Contract Levels

A meat processor purchases hogs via the market and/or purchases hogs by contracting directly with a subset of N homogeneous hog producers[2]. The number of hogs it purchases via the market will be denoted $X \in R_+$ and the number of hogs purchased on contract will be denoted $Y \in R_+$. Suppressing output price, the processor transforms acquired hogs into revenues $R(\cdot)$, where R is strictly concave. It is implicitly assumed that output price vector is known with certainty. The market exchange price of hogs is random and is denoted $m \in R_{++}$. Given hog and output prices, in the absence of contracts a representative processor's net profit is

$$\pi^1(m,X) = R(X) - mX.$$

To simplify subsequent analysis we assume that the minimum cost of producing hogs is given by $rC(\cdot)$, where r is a random index of input (e.g., feed) prices faced by hog producers and $C(\cdot)$ is the corresponding input requirement index. $C(\cdot)$ is strictly convex and twice continuously differentiable. The number of hogs the producer sells on the market is denoted $x \in R_+$ and the number of hogs it sells on contract is denoted $y \in R_+$. Given hog and feed prices, in the absence of contracts, our representative producer's net profit is

$$\pi^2(m,r,x) = mx - rC(x),$$

where x is the number of hogs produced. We assume that both processor and producer are expected utility maximizers, with the processor's expected utility given by

$$\begin{aligned} U^1 &= E_m\{\pi^1(m,X)\} - 0.5\alpha var\{\pi^1(m,X)\} \\ &= R(X) - \bar{m}X - 0.5\alpha X^2\sigma_m^2, \end{aligned}$$

and the producer's expected utility given by

$$\begin{aligned} U^2 &= E_{m,r}\{\pi^2(m,r,x)\} - 0.5\beta var\{\pi^2(m,r,x)\} \\ &= \bar{m}x - \bar{r}C(x) - 0.5\beta[x^2\sigma_m^2 + C(x)^2\sigma_r^2 - 2\rho\sigma_r\sigma_m xC(x)]. \end{aligned}$$

Here, $\bar{m} = E_m\{m\}$, $\bar{r} = E_r\{r\}$, $\sigma_m^2 = E_m(m - \bar{m})^2$, $\sigma_r^2 = E_r(r - \bar{r})^2$, and ρ is the correlation coefficient between m and r.

Define the following:

$$\bar{U}^1 = \max_X\{R(X) - \bar{m}X - 0.5\alpha X^2\sigma_m^2 \; : \; X \in R_+\}$$
$$\bar{U}^2 = \max_X\{\bar{m}x - \bar{r}C(x) - 0.5\beta[x^2\sigma_m^2 + C(x)^2\sigma_r^2 - 2\rho\sigma_r\sigma_m xC(x)] \; : \; x \in R_+\}$$

The processor's optimal choice of X satisfies:

$$\frac{dU^1}{dX} = R'(X) - \bar{m} - \alpha X\sigma_m^2 = 0, \tag{1.1}$$

and the producer's optimal choice of x satisfies:

$$\frac{dU^2}{dx} = \overline{m} - \overline{r}C'(x) - \beta[x\sigma_m^2 + C(x)C'(x)\sigma_r^2 - \rho\sigma_r\sigma_m C(x)] = 0. \tag{1.2}$$

With no contracts the processor and producers choose x so that their respective marginal revenues are equal to marginal cost plus the cost of risk. Denote the processor's optimal level of market hogs by X^* and producer's optimal level of market hogs by x^*.

Formula Contracts

As described earlier, with formula contracts, the processor writes a contract with the producer specifying the number of hogs to be delivered at a future date and the formula (based on feed prices) which will be used to determine the per unit payment for the hogs. Denote the total number of hogs to be delivered via contract by Y and the per unit payment by θr, where θ is the feed markup and r is a feed price index. We assume that the feed markup, θ, is exogenous.

The expected market price is at least as large as the expected contract price and the market price variance is at least as large as the contract price variance[3].

The processor's expected utility is

$$\begin{aligned} U_c^1(X+Y) &= R(X+Y) - \overline{m}X - \overline{r}\theta Y \\ &- \{0.5\alpha[X^2\sigma_m^2 + Y^2\theta^2\sigma_r^2 + 2\rho\theta\sigma_r\sigma_m XY]\} \end{aligned}$$

where U_c^1 is the expected utility associated with purchasing X hogs via the market and Y hogs via contract. The processor contracts only if

$$U_c^1(X+Y) \geq \overline{U}^1.$$

Assuming that the contract absorbs all of a producer's capacity[4], its expected utility from producing $y \leq Y$ hogs is

$$U_c^2(y) = \overline{r}[\theta y - C(y)] - 0.5\beta[\theta y - C(y)]^2\sigma_r^2.$$

The producer chooses *y* to satisfy the following necessary condition:

$$\frac{dU_c^2(y)}{dy} = \bar{r}[\theta - C'(y)] - \beta[\theta y - C(y)][\theta - C'(y)]\sigma_r^2 = 0$$

or
$$0 = \bar{r}\theta - \bar{r}C'(y) - \beta[\theta y - C(y)][\theta - C'(y)]\sigma_r^2.$$

Producers choose output so that expected revenues $\bar{r}\theta$, is equal to marginal production costs, $\bar{r}C'(y)$, plus the price of risk, $\beta\,[\theta y - C(y)]\,[\theta - C'(y)]\,\sigma_r^2$.

Denote the choice of output satisfying (2.1) by y^*, and define the contract as the pair (θ, y^*). The producer accepts the processor's contract only if

$$U_c^2(y^*) \geq \bar{U}^2.$$

The processor's problem is chooses *X* and *Y* to maximize U_c^1 $(X + Y)$ subject to

$$\max_{X,Y} \{U_c^1(X+Y) \ : \ U_c^1(X+Y) \geq \bar{U}^1, Y \geq y^*\}.$$

The Lagrangian for this problem is:

$$L = U_c^1(X+Y) + \lambda^1[U_c^1(X+Y) - \bar{U}^1] + \lambda^2[Y - y^*].$$

where λ^1 and λ^2 are shadow values. Necessary conditions for an optimum include:

$$0 \geq \frac{\partial L}{\partial X} = (1+\lambda^1)\{R' - \bar{m} - \alpha[X\sigma_m^2 + \rho\theta\sigma_r\sigma_m Y]\}$$
$$0 \geq \frac{\partial L}{\partial Y} = (1+\lambda^1)\{R' - \bar{r}\theta - \alpha[Y\theta^2\sigma_r^2 + \rho\theta\sigma_r\sigma_m X]\} + \lambda^2$$
$$0 \leq \frac{\partial L}{\partial \lambda^1} = U_c^1(X+Y) - \bar{U}^1$$
$$0 \leq \frac{\partial L}{\partial \lambda^2} = Y - y^*$$

and the complementary slackness conditions

$$\frac{\partial L}{\partial X}X = \frac{\partial L}{\partial Y}Y = \frac{\partial L}{\partial \lambda^1}\lambda^1 = \frac{\partial L}{\partial \lambda^2}\lambda^2 = 0.$$

<u>Processor contracts and makes market purchases</u>

Denote the optimal level of *Y* by *Y**. For an interior solution, $X^* > 0$, $Y^* > y^*$, the following system must be satisfied:

$$R^{/}(X^* + Y^*) = \overline{m} + \alpha[X^*\sigma_m^2 + \rho\theta\sigma_r\sigma_m Y^*] \tag{2.2}$$

$$R^{/}(X^* + Y^*) = \overline{r}\theta + \alpha[Y^*\theta^2\sigma_r^2 + \rho\theta\sigma_r\sigma_m X^*]. \tag{2.3}$$

By (2.2) and (2.3), the processor's optimal choice of hogs equates the expected marginal cost of market hogs and with the expected marginal costs of contract hogs. The expected marginal cost of market hogs is equal to the expected market price plus the processor's cost of market risk, $\alpha[X^* \sigma_m^2 + \rho\sigma_r\sigma_m\theta n^* y^*]$. By (2.3), the marginal cost of contract hogs is equal to the expected contract price, plus the processor's cost of contract risk. Note that if $\rho < 0$, the processor's cost of contract (market) risk decreases with increases in the number of market (contract) hogs. Given the strict concavity of *R*, expressions (2.2) and (2.3) suggest that if ρ is positive (negative), then processors will purchase fewer (more) hogs via the market than if contracts were unavailable. The implicit relationship between the number of hogs purchased via cash markets and hogs purchased through contracts is:

$$X = \frac{\overline{r}\theta - \overline{m}}{\alpha[\sigma_m^2 - \rho\theta\sigma_r\sigma_m]} + \frac{\theta^2\sigma_r^2 - \rho\theta\sigma_r\sigma_m}{\sigma_m^2 - \rho\theta\sigma_r\sigma_m}Y + \frac{\lambda^2}{(1+\lambda^1)\alpha[\sigma_m^2 - \rho\theta\sigma_r\sigma_m]}. \tag{2.4}$$

Totally differentiating the equilibrium condition (2.4) and rearranging terms gives:

$$\frac{dX}{dY} = \frac{\theta^2\sigma_r^2 - \rho\theta\sigma_r\sigma_m}{\sigma_m^2 - \rho\theta\sigma_r\sigma_m}$$

implying that
$$\frac{dX}{dY} \begin{matrix} < \\ = \\ > \end{matrix} 0 \quad as \quad \frac{\theta^2\sigma_r^2}{\theta\sigma_r\sigma_m} \begin{matrix} < \\ = \\ > \end{matrix} \rho.$$

As shown in Table 1, the variance of formula contract prices is less than that of market hog prices. Hence, for large enough ρ, the processor will trade off market purchased hogs with contract hogs. On the other hand, if the correlation between r and m is small or negative then the processor will increase the number of both market and contract hogs; possibly leading to an increase in the size of the industry.

<u>Corner solutions</u>

$$0 \geq \frac{\partial L}{\partial X} = (1+\lambda^1)\{R' - \bar{m} - \alpha[X\sigma_m^2 + \rho\theta\sigma_r\sigma_m Y]\}$$
$$0 \geq \frac{\partial L}{\partial Y} = (1+\lambda^1)\{R' - \bar{r}\theta - \alpha[Y\theta^2\sigma_r^2 + \rho\theta\sigma_r\sigma_m X]\} + \lambda^2$$

For our purposes, a corner solution occurs when either X or Y is equal to zero. If $X^* > 0$ and $Y^* = 0$, then it must be true that

$$0 > \frac{\partial L}{\partial Y} = R'(X^*) - \bar{r}\theta - \alpha\rho\theta\sigma_r\sigma_m X^*$$

or
$$R'(X^*) < \bar{r}\theta + \alpha\rho\theta\sigma_r\sigma_m X^*.$$

In other words, the marginal value product of a single contract hog is less than the sum of the expected contract hog price and cost of contract risk. Similarly, if $Y^* > 0$ and $X^* = 0$ then

$$R'(Y^*) < \bar{m} + \alpha\rho\theta\sigma_r\sigma_m Y^*$$

and the marginal value product of a single market hog is less than the sum of the expected market hog price and cost of market risk.

Empirical Model

For estimation purposes, we assume that the processor's revenue function is approximated by the quadratic function R(z) = az - bz^2, where z represents units of hogs. The representative producer's technology is proxied by the constant marginal cost function C(z) = ηz. Then by (2.2), with no contracts, the producer's expected utility is maximized when,

$$x^* = \frac{\bar{m} - \bar{r}\theta}{\beta[\sigma_m^2 + \eta^2\sigma_r^2 - \rho\theta\sigma_r\sigma_m]},$$

and by (2.3), with contracts, its expeted utility is maximize when,

$$y^* = \frac{\bar{r}}{\beta[\theta - \eta]\,\sigma_r^2}.$$

Furthermore, rearranging terms it follows that

$$x^* \begin{array}{c}<\\=\\>\end{array} y^* \quad as \quad \frac{\bar{m} - \bar{r}\theta}{\bar{r}\theta} \begin{array}{c}<\\=\\>\end{array} \frac{\sigma_m^2 + \eta^2\sigma_r^2 - \rho\sigma_r\sigma_m}{\theta^2\sigma_r^2 - \theta\eta\sigma_r^2}.$$

In other words, if the ratio of hog prices (the expected gain from market sales relative to the expected contract price) is large relative to the ratio of risk prices and the producer will choose to producer hogs under contract than if selling on the market.

Using equations (2.5) and (2.4) we see that with contracts, the processor's expected utkoity maximizing behavior of contract and market hogs are respectively,

$$Y^* = \frac{(a - \bar{r}\theta)A - (a - \bar{m})\,B}{CA - B^2}\,. \tag{3.1}$$

$$X^* = \frac{(a - \bar{m})C - (a - \bar{r}\theta)\,B}{CA - B^2}\,. \tag{3.2}$$

$$X^*_{NC} = \frac{a - \bar{m}}{A}\,, \tag{3.3}$$

and without contracts, by equation (2.1) hog demand is

where,

$$A = b + \alpha\sigma_m^2$$
$$B = b + \alpha\rho\theta\sigma_r\sigma_m$$
$$C = b + \alpha\theta^2\sigma_r^2$$

Using expressions (3.1) and (3.2) it is straightforward to show that $Y^* > X^*$ if

$$\frac{A - C}{C - B} = \frac{\sigma_m^2 - \theta^2\sigma_r^2}{\theta^2\sigma_r^2 - \rho\theta\sigma_r\sigma_m} > \frac{a - \bar{m}}{a - \bar{r}\theta}$$

Hence, the relative magnitudes of optimal contract and market hog levels is indepndent of the processor’s degree of risk aversion; they depend only on the first and second moments of contract and market hog prices, and the correlation coefficient between the two.

Denote the total number of slaughter hogs purchased on contract and on the market be denoted

$$Z^* = X^* + Y^* = \frac{(a - \bar{r}\theta)(A - B) + (a - \bar{m})(C - B)}{CA - B^2}. \tag{3.4}$$

It is easy to establish that for nonnegative ρ, $Z^* \geq X_{NC}^*$. To see this, observe that by rearranging the terms in equatinos (3.3) and (3.4), $X_{NC}^* > Z^*$ only if

$$\frac{a - \bar{m}}{a - \bar{r}\theta} > \frac{A}{B} = \frac{b + \alpha\sigma_m^2}{b + \alpha\rho\theta\sigma_r\sigma_m}$$

However, from Table 1 we know that $\bar{m} > \bar{r}\theta$ and $\sigma^2_m > \theta^2\sigma^2_r$, hence the left hand side of the above inequality is always less than 1 and the right-hand-side is always greater than 1, implying that $Z^* \geq X^*_{NC}$.

Finally, note that

$$X^* = 0 \;\; only \;\; if \;\; \frac{a - \bar{m}}{a - \bar{r}\theta} < \frac{b + \alpha\rho\theta\sigma_r\sigma_m}{b + \alpha\theta^2\sigma_r^2}$$

and

$$Y* = 0 \;\; only \;\; if \;\; \frac{a - \bar{r}\theta}{a - \bar{m}} < \frac{b + \alpha\rho\theta\sigma_r\sigma_m}{b + \alpha\sigma_m^2}$$

The following results emerge immediately: (I) if ρ is small enough one need not fear the market dissappearing, but if ρ is "large" X^* cpi;d temd tp zero; (ii) regardless of the size of ρ, Y^* will never tend to zero.

Empirical Estimation and Results

Given the above derivation of the empirical model, it is conceptually plausible to provide empirical estimates of the optimal level of contracting (Y^*), the optimal level of market hog purchases (X^*) and whether the total number of hogs purchased under a contracting regime ($Z^* = Y^* + X^*$) is greater than under a market regime (X^*_{NC}). These values concide with the estimation of equations 3.1 through 3.3. It is only necessary to estimate two coefficients a and b. These can be estimated using data on total hogs purchased (slaughtered), market price levels, calculated contract price levels used in table 1, and the variance, covariance and correlation of prices. It is also empirically appealing that using the property that contracted and non-contracted hogs must sum to the total of all hogs slaughter, that equations 3.1 and 3.2 can be condensed into a single share equation estimate which follows:

$$w_y = \frac{(a - \bar{r})A - (a - \bar{m})B}{(a - \bar{r}\theta)A + (a - \bar{m})C - 2ab + (\bar{m} + \bar{r}\theta)B}$$

Where, w_y is the share of hogs contracted by the processor and $w_y = Y^*/Z^*$. From this it also follows that $w_x = 1 - w_y$. However, it is impossible to obtain a time series of the share of hogs contracted by processors in order to be able to estimate this equation. That is, the dependent variable is unobservable. To overcome this problem, we propose the following four step analytical proxy.

The first step is to estimate the parameters a and b for the market under the assumption of no contracting availability. Most market contracts of the type we're discussing have been developed since

1992. Therefore, the period 1980 - 1990 is taken to represent a period of no long term contracts, so that market derived quanities X^*_{NC} are the optimal levels of hogs under no contracts and is equal to Z* for that period of time (i.e., Y* = 0). For our purposes, X^*_{NC} is Federally Inspected Monthly Hog Slaughter as reported by USDA and we need only estimate equation 3.3. Prices are the monthly average six-market barrow and gilt prices.

The second step is to use the estimates of a and b as prior estimates to simulate optimal contract levels Y* and non-contract levels X* and hence the total market volumes under a regime which allows for long term contracts. These values can in turn be compared directly to the single estimate of actual contracting levels reported by Hayenga,et. al. In addition, this will make it feasible to conduct sensitivity analysis (the third step) of the contracting levels to values of the proxy parameters a and b. In addition, we will be able to simulate implications in changes to the moments of the distribution of prices. This will provide insights into critical market factors affecting contract levels. The bottom line is we will be able to see if price incentives are great enough to alone explain incentives for increased levels of long term contracting, or if it is likely that there are other external factors such as quality assurance or information accessibility which are key drivers.

As a fourth and final step, we will estimate parameters a and b from shares reported by Hayenga et al. For the period 1992-1994, assuming constant shares (quanities will vary because of observed variances in slaughter levels accross the years. This will provide some information as to whether the original parameters estimated for the period 1980-1990 are reasonable proxies. One may think of this analysis as being similar to calibration studies wherein unobservable parameters are used as proxies to perform simulations.

Estimation of Proxy Parameters

The equation X^*_{NC} to be estimated takes the form:

$$X^*_{NC} = \frac{a - \overline{m}}{b + \alpha\sigma^2_m} + \nu_t$$

where, X^*_{NC} is the optimal level of hog procurement or slaughter, *a* and *b* are parameters to be estimated, α is the risk aversion parameter and ν_t is the error term where $\nu_t \sim IID\ (0, \sigma^2)$

Conclusions

The above analysis suggests that optimal formula contract levels depend explicitly on the correlation between corn and hog prices, and that the optimal level of contracting is an empirically tractable question which is of great importance for maintaining the efficient conduct and performance of hog markets. Currently, we are in the process of completing this empirical analysis. Moving from the theoretical model to an empirical one is relatively straightforward. A quadratic profit function has been specified and we have the data necessary to complete the analysis. If accepted, a complete version of the paper including empirical results will be presented at the selected paper session. To give an idea of intended future work, subsequently we intend to relax the the homogeneity of producers assumption and allow production risk enter the system also.

Endnotes

[1] For instance, say a processor has a feed indexed formula contract with hog producers. Then it is quite possible that the contract price may at times be significantly higher than the market price, meaning that the processor will have higher input costs than its competitors who do not offer such contracts.

[2] In general it requires several producers to fill the slaughter capacity of one hog processor. We impose this requirement so that a processor may incrementally change its contracting level my adding or removing producers from its procurement set.

[3] This is often a point of confusion when discussing long-term market agreements. As shown in the simulation estimates of table 1, the actual contracts have lower average prices and lower price variation than the market price. The *price received* by the producer will by quite different from this base market price or base formula price due to carcass merit premiums paid on the quality of the hog. However, it is empirically obvious from table, 1 and assuming no measurement error of the quality of the hog carcass, that price received under market price conditions is expected to be higher than the price received under contract. If contracted hogs were consistently higher quality than their market hog counterparts, it is possible that the price received for contracted hogs would be greater than the price received for market hogs. This difference may also reverse if the packer passes some of the cost savings from reduced procurement costs on to the producer. However, we have explicitly assumed no quality variation, so that market hog prices are in general greater than the contract prices.

[4] As indicated in the description of contracts, packers may require their relationship with producers to be exclusive.

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