Examining Packer Choice of Slaughter Cattle Procurement and Pricing Methods

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Using daily fed cattle purchase transaction records collected by the Packers and Stockyards Program over the period April 1992 to April 1993, we identify characteristics associated with the choices of fed cattle procurement and pricing methods. The methodology involves the use of a multinomial logit model.

Regional concentration; processing capacity; number of head per lot; average weight per head; cattle type; yield grade, quarterly grade, seasonality, and distance from packing plants play a significant role in determining the methods of procurement and pricing chosen by packers. The method chosen by packers to procure fed cattle also affects the choice of a given pricing method.

While procurement and pricing policies may be made at the firm or plant level, the actual procurement and pricing decisions are often made in the field by cattle buyers salaried by meat packers or employed on a commission basis. Ward (1979, 1988), by way of case study interviews of beef packing companies, provided descriptive information on the pricing process and procurement practices of beef packers. Further, Ward (1981) conducted a follow-up effort to empirically address the fed cattle pricing process and procurement practices. Sale price for each lot of cattle on a live-weight basis was linked to wholesale carcass price, the live cattle futures market price, average live weight of cattle in the lot, average dressing percentage of cattle in the lot, number of head in the sale lot, distance from the feed lot to slaughter plant, types of cattle in the lot, number of days between purchase date and delivery date for the lot, buyer-seller negotiating range, number of bids received per lot, and region. Ultimately, a number of factors may affect the procurement and pricing methods chosen for different lots of cattle, including characteristics related to the purchasing plant or firm, the fed cattle seller, the particular lots of fed cattle purchased, and the slaughter and sale of beef by packers.

The share of cattle slaughtered by the top four firms in the beef cattle industry has risen dramatically in the past two decades. Between 1980 and 1994, the four-firm concentration ratio in beef packing increased from about 36% to 81%. The rise in concentration in the beef packing industry had led to concerns over procurement and pricing practices of packers. This issue is of concern because increased vertical integration through packer feeding and captive supplies reduces the role of public markets where the terms of trade are more visible and may leave the market vulnerable to price manipulation.

Azzam and Anderson (1996) provided a rich historical perspective of literature dealing with livestock prices and concentration. Econometric models developed for testing hypotheses regarding noncompetitive conduct have been applied to the beef processing industry by Menkhaus et al. (1981), Schroeter (1988), Azzam and Schroeter (1991), and Marion and Geithman (1995). The commonality of the findings of these studies is that concentration, generally measured either by the four-firm concentration ratio or the Herfindahl index, is negatively related to live cattle prices.

Several studies have focused on the effects of captive supplies on prices paid by packers. Captive

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supplies are defined as slaughter cattle produced through packer feeding in packer-owned and commercial feedlots; or forward contracts, including cash price and basis forward contracts, and exclusive marketing agreements with individual cattle feeding firms (Ward et al. (1996)). Ward et al. (1996) concluded that: (1) captive supply behavior does not appear to be systematically related to plant location or region; (2) prices play a major role in determining the level of captive supplies among the largest processing plants, but they do not influence these levels among the smallest plants; and (3) plant utilization is a key determinant of captive supplies for both large and small cattle packing plants. Ward and Bliss (1989) surveyed 3,700 cattle feedlots in 1989 to estimate the extent of forward contracting and to obtain perceptions by cattle feeders of reasons for using contracts. Elam (1992) and Schroeder et al. (1993) found that packer-controlled supplies lowered monthly average fed cattle prices, while Hayenga and O'Brien (1992) found little evidence that forward contracting diminished fed cattle prices.

To date, however, little work has been done in identifying and assessing potential determinants of the choice of slaughter cattle procurement and pricing methods. Consequently, there is little understanding as to why certain cattle procurement and pricing methods are selected. This research attempts to fill this void. Using daily fed cattle purchase transactions records collected by the Packers and Stockyards Program (PSP), Grain Inspection Packers and Stockyards Administration (GIPSA), U.S. Department of Agriculture, this paper reports on an analysis designed to identify those characteristics associated with the choices of fed cattle procurement and pricing methods. The data, available only from GIPSA due to its proprietary nature, are from the top 43 steer and heifer packing plants for the period April 5, 1992 to April 3, 1993.

After laying out the underlying methodology and the model to be used, the transactions data as used for this analysis are described. The empirical results are then discussed including some indication of the predictive ability of the model. Following a brief discussion of the limitations of this study, conclusions and implications of the empirical results related to the procurement and pricing practices of the top beef packers are discussed.

Methodology

A polychotomous choice model is used to identify and measure the effects of transactions characteristics that may affect the choice of cattle procurement method and the choice of lot pricing method by packers during the period of the data. Discrete choice models have become invaluable tools in characterizing selection from among finite sets of alternatives. In situations where individuals confront unordered choices involving a single decision among two or more alternatives, the multinomial logit model (Theil (1969), McFadden (1974), and Domencich and McFadden (1975) can be used to estimate the probability that any particular choice will be made. Maddala (1983) and Greene (1993) provided extensive reviews of this literature. After discussing the application of this type of model for analyzing procurement and pricing method choices by packers, the model specification used for the analysis is considered.

The Polychotomous Choice Model and Cattle Procurement and Pricing Choices

For both procurement and pricing methods, the dependent variables of the polychotomous choice model correspond to discrete values from 0 to $k-1$, where k refers to the maximum number of procurement or pricing methods. Cattle procurement and lot pricing methods are examples of *unordered* categorical variables. That is, they are dependent variables whose values may be defined in any order desired.

Because the dependent variables correspond to discrete values, the probability that the jth procurement or pricing method is chosen, conditional on the given transactions characteristics, can be investigated. Since procurement and pricing methods are represented by unordered variables and because there are 4 procurement methods and 3 pricing methods, the analysis requires the use of the multinomial logit model.

In the multinomial logit model, for the ith observation corresponding to a set of right-hand-side (RHS) variables (x_i), the probability of the selection of choice j is given as:

$$(1)\quad P_{ij} = \frac{\exp(B_j x_i)}{\sum_{j=0}^{k-1} \exp(B_j x_i)} \qquad j = 0, 1, \ldots, k-1$$

where P_{ij} is the probability that for the ith observation (for $I = 1, \ldots, n$), choice j is made; the B_j are the parameters to be estimated; and $k = 4$ for procurement methods and $k = 3$ for pricing methods. Following Greene, the normalization rule is that $B_0 = 0$. Each observation must fall into one of

the k types of procurement of pricing methods. Hence, for all i:

$$\sum_{j=0}^{k-1} P_{ij} = 1. \tag{2}$$

Letting $y_{ij} = 1$, if the ith observation falls into the jth type category, and letting $y_{ij} = 0$ otherwise, the likelihood function for the multinomial logic model can be written as:

$$L = \prod_{i=1}^{n} P_{i0}^{y_{i0}} P_{i1}^{y_{i1}} \ldots P_{ik-1}^{y_{ik-1}} \tag{3}$$

or as:

$$\log L = \sum_{i=1}^{n} \sum_{j=0}^{k-1} y_{ij} \log P_{ij} \tag{4}$$

To determine estimates of the parameters B_1, B_2, . . . , B_k, the aforementioned log-likelihood function is maximized. However, because the log-likelihood function is nonlinear in parameters, an iterative estimation procedure must be used. Given the maximization of the log-likelihood function, likelihood ratio tests can be used to determine which of the exogenous transactions characteristics are statistically significant. Also, after deriving estimates of the parameters $B_1, B_2, \ldots, B_k$, the probabilities that for the ith observation of jth type of procurement or lot pricing methods is chosen can be computed. Estimation of the multinomial logit model requires the use of specialized computer software. For this analysis, the LIMDEP package is used (Greene).

To derive marginal effects in the multinomial logit model, consider $\partial P_{ij}/\partial x_{ij}$, the change in the probability of the jth choice given a change in x_i, which is given as:

$$\frac{\partial P_{ij}}{\partial x_i} = P_{ij}\left[B_j - \left(\sum_{j=0}^{k-1} B_j P_{ij}\right)\right] \tag{5}$$

$$j = 0, 1, \ldots, k-1$$

Neither the sign nor the magnitude of $\partial P_{ij}/\partial x_{ij}$ need bear any relationship to those of the B_j. Note also that for a given x_i, the marginal effects sum to zero across all types of a procurement or pricing method:

$$\sum_{j=0}^{k-1} \frac{\partial P_{ij}}{\partial x_i} = 0 \tag{6}$$

That is, given changes in x_i, if the probability of a choice rises, at least one probability must fall. The marginal effects may also be converted into elasticities as follows:

$$\varepsilon_{ij} = \frac{\partial P_{ij}}{\partial x_i}\frac{x_i}{P_{ij}} = \left[B_j - \left(\sum_{j=0}^{k-1} B_j P_{ij}\right)\right] x_i \tag{7}$$

$$j = 0, 1, \ldots, k-1.$$

The multinomial logit model may be used to predict the choices made in the procurement and pricing decisions. Given the set of RHS variables x_i, as well as the estimated coefficient vectors B_1, B_2, . . . , B_{k-1}, the associated probabilities P_{i0}, P_{i1}, . . . , P_{ik-1} may be computed. The maximum of (P_{i0}, P_{i1}, . . . , P_{ik-1}) is then the prediction of the procurement or lot pricing method chosen for a particular lot.

The following contingency table, also known as a prediction-success table, can be used to determine the usefulness of the multinomial logit model for prediction purposes:

		PREDICTION					
		0	1	2	. . .	$k-1$	Total
ACTUAL	0	d_0					n_0
	1		d_1				n_1
	2			d_2			n_2
	–				–		–
	$k-1$					d_{k-1}	n_{k-1}
	Total						
		m_0	m_1	m_2	. . .	m_{k-1}	n

The n_0, n_1, n_2, . . . , n_{k-1} in the table refer to the number of observations corresponding to actual outcomes of the choices made. The m_0, m_1, m_2, . . . , m_{k-1} refer to the observations corresponding to the predicted outcomes in a particular category. The d_0, d_1, d_2, . . . , d_{k-1} refer to the number of observations for which the actual outcomes and the predicted outcomes match. For example, if $P_{i0} = .43$, $P_{i1} = .17$, $P_{i2} = .07$, and $P_{i3} = .33$ (note that the sum of these hypothetical probabilities equals 1), then the predicted outcome is that associated with the subscript 0 (the first of the four possibilities) since it has the highest probability. If, in this case, the actual outcome is also the first of the four choices, then the model made a successful prediction. Consequently, the diagonal elements of the prediction-success table (d_0, d_1, d_2, . . . , d_{k-1}) indicate the ability of the model to make successful predictions. Thus, a measure of the multinomial logit model in making successful predictions is given by:

$$\frac{\sum_{j=0}^{k-1} d_j}{n} \tag{8}$$

For each outcome the predictive ability of the model can be determined as:

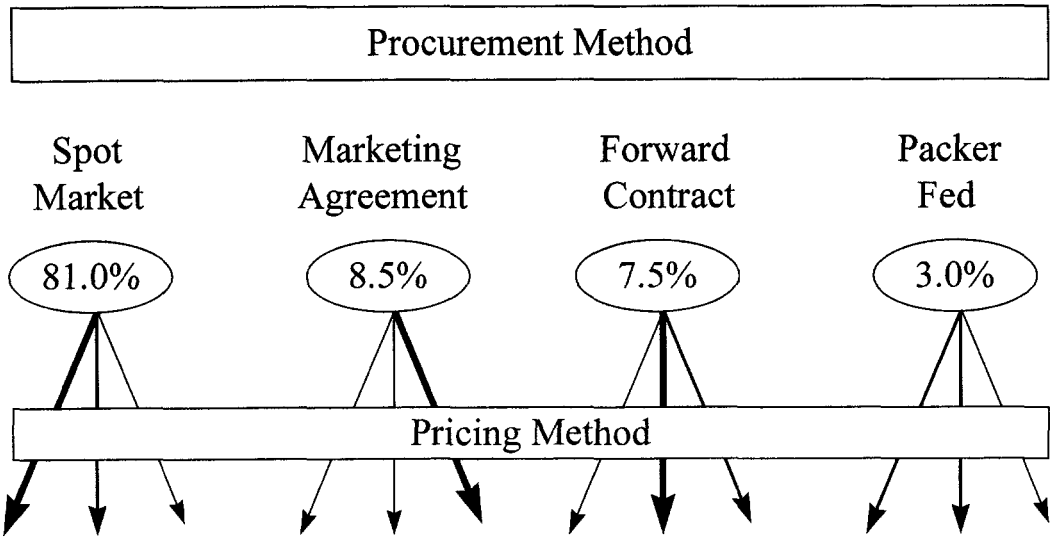
$$\frac{d_0}{n_0}, \frac{d_1}{n_1}, \frac{d_2}{n_2}, \ldots, \frac{d_{k-1}}{n_{k-1}}. \tag{9}$$

Model Specification

The specification of the model follows in large part from the discussion by Ward (1979; 1981; 1988) of the factors affecting slaughter cattle procurement and pricing. In this analysis, procurement methods include: (1) the open or spot market, (2) marketing agreements, i.e., long-term purchase arrangements in which the packer agrees to purchase a specified number of cattle per specified time period, (3) forward contracting, and (4) packer fed/owned. Pricing methods include: (1) liveweight, (2) carcass weight, and (3) formula, e.g., pricing based on a packer's weekly average prices paid or on an average of two or more price reports.

The right-hand side (RHS) variables in the polychotomous choice model for procurement are postulated to include the following: (1) output price of beef; (2) maximum slaughter capacity; (3) capacity utilization; (4) the number of cattle in the lot; (5) the average weight per head in the lot; (6) the number of days elapsed between purchase and slaughter; (7) the regional Herfindahl index; (8) the distance in miles between the seller and the packer; (9) seasonality; (10) cattle type; (11) yield grade of the lot; and (12) quality grade of the lot. Right-hand side variables in the pricing model are the same except that the procurement method is added.

Thus, the only difference in the specification of the two models is that the lot pricing method model includes the procurement method as an RHS variable while the reverse is not true. In other words, procurement and pricing decisions are hypothesized to be recursive. By hypothesis, procurement decisions are made initially independent of pricing decisions. The lot pricing method choice, on the other hand, is hypothesized to be affected by the choice of procurement method. For example, if the procurement method is the spot market (which comprises approximately 81% of the transactions according to the transactions data), then the pricing method is generally either liveweight or carcass weight (figure 1). By the same token, if the procurement method is forward contracting or packer



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Source: GIPSA data

Figure 1. Percentage of Transactions by Pricing Method Conditional on Procurement Method

fed cattle (7.5% and 3.0% of the transactions, respectively), then the most predominant lot pricing method is carcass weight.

The *output price* as defined and used in this analysis is the weighted average revenue per lb received for seven types of beef output shipped by each packer: (1) whole carcass equivalents, (2) primals, (3) sub-primals, (4) other fabricated cuts, (5) trimmings, boneless beef, or grinding material from fabrication operation, (6) carcass beef (whole, halves, quarters), and (7) by-products, variety meats, and kill floor grinding material. Output price reflects the demand for beef at the next level of the marketing channel. The output price information was made available by GIPSA from their Beef Packer Costs and Returns Survey (BPCRS) by packing plant and by week (U.S. Department of Agriculture, Packers and Stockyards Program).

Information on *slaughter capacity* also was provided from the BPCRS by GIPSA. Only two observations on slaughter capacity were collected for each plant, one for the first day of the period (April 5, 1992) and the other for the last day of the period (April 3, 1993). If the plant capacity is different on the two dates, the maximum of the two capacity observations is used in our analysis. Slaughter capacity (measured as number of head slaughtered per hour) is a proxy variable for returns to scale in plant operations. Slaughter capacity is the same across weeks but varies by plant.

Procurement and pricing methods also may depend in part on *characteristics of the purchase lots.* The model includes several lot characteristics as RHS variables, including: (1) the number of cattle in the lot; (2) the average weight of the lot; (3) cattle type; (4) yield grade; and (5) quality grade of the lot. The first is a simple count of the number of cattle in the lot. The second is the total liveweight of the lot divided by the number of cattle in the lot. Cattle types include: (1) dairy; (2) fed Holsteins; (3) steers; (4) heifers; and (5) mixed. Because cattle type is a qualitative factor, dummy variables are used to account for this attribute of the purchase lots. Historically, a high percentage of Holsteins have been sold via contract. Mixed sex lots are more often sold on a live weight basis; mixed sex lots also are usually the smaller lots.

Dummy variables are also used to account for yield grades and quality grades of the lots. Two groups of variables are included to capture these important quality characteristics intrinsic in each lot. The first group is represented by three dummy variables corresponding to the prominent yield grade in each lot: (1) lots that are predominantly yield grade 1 (YG1), (2) lots that are predominantly yield grade 2 (YG2), and (3) lots that are predominantly yield grades 3, 4, and 5 (YG3). The second group of quality variables is a series of dummy variables representing lots that are predominantly prime (P), choice (C), or select (S).

Because transactions take place over the period of a year (April 5, 1992, to April 3, 1993), procurement and pricing methods vary by season. Quarterly dummy variables are employed to represent *seasonality* for the following three-month periods: (1) April 1992 to June 1992, (2) July 1992 to September 1992, (3) October 1992 to December 1992, and (4) January 1993 to April 3, 1993. Prior work conducted by Ward and Bliss (1989) and Ward et al. (1996) suggest that April and June are typically the months with more forward contracting.

Ward (1979, 1988) suggests that most cattle are purchased for a specific plant from within a 100-mile radius of that facility, whether the owning firm had one or several slaughtering plants. He also found that some cattle are regularly purchased from between 100 to 300 miles away from the plant depending on cattle feeding density and competition. Consequently, three *seller/packer distance relationships* are represented in the model: (1) less than 100 miles from the seller to the packer; (2) between 100 and 300 miles from the seller to the packer; and (3) greater than 300 miles from the seller to the packer. These distance relationships are not explicitly part of the transactions data provided by PSP. Rather, the distances were calculated given the location of the packers and the sellers as provided in the transactions data. Each transaction was then categorized into one of the three distance groups.

Cash purchases are delivered, by trading tradition, or convention, within two weeks of slaughter, usually within fewer days. Forward contracts typically will not be entered into unless there exists more than two weeks prior to slaughter. Thus, the amount of time cattle are purchased and/or held before slaughter certainly may affect the procurement and/or pricing decisions made by packers.

Sellers may believe packers have a relative advantage in cattle transactions for several reasons: (1) there are relatively few packers to which they can sell their fed cattle; (2) packers buy cattle frequently; (3) packers operate in a specific geographic area; and (4) packers have direct contact with retailers and food service firms. It is true that meat packing is geographically more concentrated than either feeder calf production or cattle feeding. Packers typically locate plants near the source of cattle supplies rather than near densely populated

areas of consumers. Colorado, Illinois, Iowa, Kansas, Minnesota, Nebraska, Texas, and Wisconsin were the principal states involved in meat packing during the period of the transactions data. Under typical conditions, a particular meat packing plant has a limited procurement area because of the cost of transporting cattle long distances. Thus, meat packer concentration also is higher within certain states than nationally.

To determine regional differences in procurement and pricing methods, nine regions were developed using two criteria: (1) geographical location of the plant and (2) procurement area for the plant. The regions were designated as follows: (1) Nebraska, (2) Texas, (3) Kansas, (4) Colorado, (5) California and Arizona, (6) Idaho, Washington and Utah, (7) Iowa and Illinois, (8) Wisconsin and Minnesota and (9) Pennsylvania. To determine these regional definitions, plant location was first considered. A plant was assigned to the region in which it was located. For example, a plant located in Nebraska would be assigned to region 1. Next, procurement patterns were examined. If a plant purchases a majority of cattle from a region outside its physical location, it was reassigned to a different region. For example, if a plant was located in Nebraska but purchased a majority of its cattle from Kansas, the plant was reassigned to region 3.

Although there are 20 firms represented in the transactions data, complete data to perform the multinomial logit analysis were available only *for 13 firms.* Firms may have multiple plants. To account for packer concentration in the cattle procurement market, a *Regional Herfindahl-Hirschman Index* (RHHI), the most commonly used measure of industry concentration, is included in both the procurement method model and the pricing method model as a measure of market power in the input market. In 1992, the Department of Justice and the Federal Trade Commission issued the *Horizontal Merger Guideline* which defines market concentration using the Herfindahl-Hirschman Index (HHI). The HHI is calculated as the sum of the squared market shares of each firm in the industry. For example, if an industry has five firms with market shares of 30%, 20%, 20%, 20%, and 10%, then the HHI is 2200 ($=30^2 + 20^2 + 20^2 + 20^2 + 10^2$).

Competition among firms varies by state. The number of meat packing firms in each region included in the transactions data range from two to five. In the Ward studies, packers typically had two to four principal competitors in their respective areas. The RHHIs constructed using the previously defined regions are reported in table 1.

Table 1. Packer Firm Concentration Patterns by Region

Region	% of National Volume	Regional Four Firm Concentration Ratio	RHHI[1]
1. Nebraska	17.9	97.0	3138
2. Texas	18.4	98.0	4179
3. Kansas	25.7	95.0	2610
4. Colorado	D	D	D
5. California and Arizona	D	D	D
6. Idaho, Washington and Utah	7.6	100.0	3914
7. Iowa and Illinois	13.0	97.5	4451
8. Wisconsin and Minnesota	5.3	100.0	3658
9. Pennsylvania	D	D	D

[1]The Regional Herfindahl-Hirschman Indices as defined in the text.
D = Deleted to avoid disclosure.

Description of the Data

Both transactions and "non-transactions" data items from the BPCRS as provided by the GIPSA were used in this analysis. The non-transactions items were used to compute the output price of beef and maximum slaughter capacity variables and were then merged with the transactions data. The transactions data set includes observations on 200,616 lots of fed cattle slaughtered during April 5, 1992, through April 3, 1993. Transactions data for 4 steer and heifer packing plants were incomplete and dropped from the analysis. Consequently, the data set used for this analysis includes only the data for 39 of the 43 steer and heifer packing plants represented in the transactions data.

Also, missing observations and/or zero observations pertaining to RHS variables were omitted. For this analysis, 303 observations were considered to be outliers and deleted from the data set for several reasons. First, 142 observations corresponding to an output price of $0.27 per pound and 117 observations corresponding to an output price of $0.17 per pound were deleted. Second, 15 observations for which average weights per head of cattle were less than 800 pounds or greater than 1,900 pounds were deleted. Finally, we deleted observations for which delivered liveweight cost/lb was less than $0.40 or greater than $1.08. Thus, the final tally of transactions used to perform the multinomial logit model analysis was 182,007 for the 39 steer and heifer plants.

Descriptive statistics of the variables used in the respective model specifications are provided in

table 2. The representative (average) lot contained about 120 head of cattle with an average liveweight per head of about 1,170 lb. An average of 12 days elapsed between procurement and slaughter. On average, the maximum slaughter capacity was about 280 head per hour. The weighted average revenue from beef sales (output price) was $1.26 per pound. The mean RHHI was 3,865. Roughly 53% of the cattle were purchased by the packer from sellers within 100 miles of the plant, 32% were purchased from sellers between 100 and 300 miles away from the plant, and the remaining 15% from plants over 300 miles away from the plant.

About 23% of the cattle were slaughtered between January and April of 1993, 25% between April and June of 1992, 26% between July and September of 1992, and 26% between October and December of 1992. Lots with a majority of steers comprised 55% of the number of transactions, while lots with a majority of heifers comprised nearly 33%. The remainder were lots with a majority of either dairy cattle, mixed cattle, or fed Holsteins.

About 81% of the cattle lots were procured through the spot market. Only 9% were procured through marketing agreements, 8% through forward contracts, and 3% through packer fed arrangements. Roughly 44% of the lots were priced on a liveweight basis, 38% on a carcass weight basis, and 18% on a formula basis.

A closer inspection of the data indicates widely different cattle procurement and pricing practices by region (tables 3 and 4). On a regional basis, most of the cattle were procured through the spot market (table 3). The percentage of cattle obtained through the spot market ranged from a low of 58% for California and Arizona to a high of nearly 100% for Wisconsin and Minnesota. In Nebraska, Texas, and Kansas, forward contracting was used for about 8% to 12% of the cattle procured in those regions. In California and Arizona, nearly 38% of

Table 2. Descriptive Statistics Across All Regions and Packer Firms[1]

Variable	Mean	Std Dev	Min	Max
Number of head in the lot	120	98.45	1	1,584
Liveweight of the lot (lb)	139,033	113,979	1,031	1,676,098
Elapsed days (days)	12.34	30.04	0	240
Delivered cost per lb ($)	0.75	0.04	0.41	1.07
Output price ($/lb)	1.26	0.17	0.76	1.80
Maximum slaughter capacity (head slaughtered per hour)	278	74.91	D	D
Average weight (lb)	1,171	101.05	805	1,899
National firm share	0.2455	0.1313	D	D
Regional firm Herfindahl-Hirschman Index	3,865	1,185	2,610	10,000
Seasonality (% of transactions occurring in:)				
Quarter 1	23.4	0.4239	0	100
Quarter 2	25.1	0.4336	0	100
Quarter 3	26.4	0.4406	0	100
Quarter 4	25.1	0.4336	0	100
Distance from Seller to Packer (% of cattle purchased within:)				
100 miles	52.6	0.4992	0	100
100 and 300 miles	32.5	0.4683	0	100
Over 300 miles	14.9	0.3560	0	100
Cattle Type (% lots with a majority of:)				
Dairy cattle	4.0	0.1961	0	100
Mixed cattle	6.4	0.2441	0	100
Fed Holsteins	2.0	0.4974	0	100
Steers	55.1	0.4685	0	100
Heifers	32.5	0.1400	0	100
Procurement Method (% of lots procured through:)				
Forward contract	7.5	0.2638	0	100
Packer fed arrangement	3.0	0.1702	0	100
Marketing agreement	8.6	0.2794	0	100
Spot market	80.9	0.3927	0	100
Lot Pricing Method (% of lots priced on:)				
Carcass weight basis	37.9	0.6372	0	100
Formula basis	18.2	0.5701	0	100
Liveweight basis	43.9	0.4963	0	100

[1]Number of observations for each variable = 182,007.
D = Deleted to avoid disclosure.

Table 3. Procurement Methods by Region

Region	Cattle Lots Procured Through: Forward Contracts	Packer Fed Arrangements	Marketing Agreement	Spot Market
	%			
1. Nebraska	8.1	0.5	2.5	88.8
2. Texas	8.8	2.2	18.7	70.1
3. Kansas	12.2	0.3	11.0	76.4
4. Colorado	D	D	D	D
5. California and Arizona	0.0	37.7	4.4	57.9
6. Idaho, Washington and Utah	2.7	6.8	24.3	66.2
7. Iowa and Illinois	4.6	0.0	5.4	90.0
8. Wisconsin and Minnesota	3.8	0.1	0.2	95.9
9. Pennsylvania	D	D	D	D

D = Deleted to avoid disclosure.

the cattle lots procured were packer fed. Marketing arrangements were used for 11%, 19%, and 24% of the cattle lots procures in the Kansas, Texas, Idaho, Washington, and Utah regions, respectively. Regionally, in Nebraska, Wisconsin and Minnesota, most cattle were priced on a carcass weight basis. In Idaho, Washington, and Utah, cattle were priced predominantly on a formula basis. In the remaining region, the most common pricing method was liveweight pricing.

Empirical Results

The factors associated with the choice of procurement and pricing methods across all firms and regions are analyzed. The estimated coefficients and the associated marginal effects from the multinomial logit models corresponding to procurement and pricing methods across all firms and regions are provided in tables 5 and 6. As in any econometric analysis, there exists some interrelatedness among explanatory variables, such as those corresponding to characteristics of the purchase lots. Inspection of pairwise correlations among all explanatory variables suggests that this collinearity issue is not a problem. This result is attributable in large part to the massive set of observations used in the analysis.

Table 4. Pricing Methods by Region

Region	Percent of Cattle Lots Priced on: Carcass Weight Basis	Formula Basis	Liveweight Basis
	%		
1. Nebraska	65.9	4.6	29.4
2. Texas	14.1	23.9	61.9
3. Kansas	21.9	17.5	60.6
4. Colorado	D	D	D
5. California and Arizona	16.4	4.3	79.3
6. Idaho, Washington, and Utah	23.5	74.7	1.8
7. Iowa and Illinois	39.0	19.9	41.1
8. Wisconsin and Minnesota	52.4	5.0	42.6
9. Pennsylvania	D	D	D

D = Deleted to avoid disclosure.

Procurement Methods

In the procurement methods choice model, all but four coefficients are statistically significant at the 0.05 level of significance. Using equation (1) and the estimated coefficients from table 5, the probabilities of procurement method choice across all packers at the sample means of the RHS variables are calculated as: (1) 0.89 for the spot market, (2) 0.07 for marketing agreements, (3) 0.03 for forward contracting, and (4) 0.01 for packer fed. This set of probabilities corresponds closely to the percentage of transactions by procurement method.

The marginal effects, corresponding to changes in probabilities of procurement method selection due to unit changes in the RHS variables, are provided in table 5 for all RHS variables. The changes in probabilities are converted to elasticities for the continuous variables: (1) slaughter capacity; (2) capacity utilization; (3) output price; (4) number of head per lot, (5) average weight per head; (6) elapsed days; and (7) regional firm concentration. By placing emphasis on elasticities for the "continuous" variables, marginal effects are not sensitive to units of measurement.

As indicated by the marginal effects, a 1% increase in *slaughter capacity* results in an increase

Table 5. Estimated Coefficients and Marginal Effects in the Multinomial Logit Model for Procurement Methods Over All Firms and Regions

RHS Variable	Estimated Coefficients[1]			Marginal Effects[2]			
	B1	B2	B3	Forward Contracts	Packer Fed	Marketing Agreement	Spot Market
Capacity	−0.0073	−0.0021	−0.0025	0.000063	−0.000052	0.000027	−0.000037
	(−20.40)	(−6.74)	(−8.65)	[0.6947]	[−1.3385]	[0.1012]	[−0.0116]
Capacity Utilization	−4.7395	0.2710*	−1.1875	0.027268	−0.039790	0.100900	−0.088378
	(−27.04)	(1.75)	(−8.59)	[0.4851]	[−1.6279]	[0.6060]	[−0.0443]
Output Price	3.0706	1.8698	1.4222	−0.036027	0.017794	0.032073	−0.003839
	(21.58)	(14.99)	(12.55)	[−1.8178]	[2.0644]	[0.5462]	[0.0197]
Number of Head	0.0050	−0.0006	−0.0016	0.000036	0.000071	0.000061	−0.000168
	(25.86)	(−3.31)	(−8.57)	[0.1722]	[0.7756]	[0.0989]	[−0.0226]
Average weight	−0.0027	−0.0039	−0.0004	−0.000017	−0.000022	−0.000240	0.000244
	(−10.01)	(−16.73)	(−1.97)	[0.8140]	[−2.3362]	[−3.7893]	[0.3218]
Elapsed Days	−0.0305	−0.0820	−0.1019	0.002433	0.000725	0.001119	−0.004277
	(−40.65)	(−57.18)	(−98.36)	[1.1988]	[0.8218]	[0.1861]	[−0.0593]
Regional HHI	0.0009	0.0000*	0.0001	−0.000002	0.000009	−0.000004	−0.000003
	(37.35)	(1.12)	(3.89)	[−0.3249]	[3.1758]	[−0.2250]	[−0.0110]
Quarter 1	−0.3492	−0.3465	−0.2281	0.005825	−0.001273	−0.008467	0.003915
	(−5.47)	(−6.36)	(−4.57)				
Quarter 2	−0.4602	−0.6841	−0.4498	0.011427	−0.000046	−0.016936	0.005555
	(−7.60)	(−13.38)	(−9.84)				
Quarter 3	0.9710	0.9815	0.9480	−0.023228	0.000479	0.004046	0.021870
	(13.89)	(15.64)	(16.05)				
Dairy	−0.8200	−2.8990	−2.9083	0.070463	0.021708	−0.006460	−0.085711
	(−9.89)	(−30.80)	(−48.09)				
Fed Holsteins	−2.9803	1.7859	0.5595	−0.014982	−0.038993	0.088190	−0.014215
	(−2.95)	(9.36)	(2.96)				
Heifers	−0.1836	−0.7493	0.0406	−0.000538	−0.001766	−0.054032	0.055261
	(−3.21)	(−15.08)	(10.89)				
Mixed	−4.6775	−2.4186	1.1687	−0.020282	−0.059793	−0.239628	0.319703
	(−17.28)	(−9.74)	(7.95)				
D100[3]	3.3027	1.3846	0.8488	−0.022403	0.026248	0.036418	−0.040263
	(42.68)	(27.03)	(18.67)				
D100/300[4]	1.7151	0.9411	0.8470	−0.021105	0.009512	0.007335	0.004258
	(21.83)	(17.49)	(17.87)				
Yield Grade 1	−0.9871	−2.0349	−0.1953	0.008410	−0.007100	−0.126146	0.124836
	(−8.66)	(−19.81)	(−2.70)				
Yield Grades 3, 4, 5	0.3071	−0.5265	−0.2205	0.005812	0.005874	−0.021867	0.055181
	(6.55)	(−13.04)	(−5.95)				
Select	0.2261	−0.1079	0.0412*	−0.000781	0.002124	−0.010320	0.008977
	(4.33)	(−2.31)	(0.96)				
Constant	−3.1905	4.6073	3.9517				
	(−7.62)	(12.68)	(11.97)				

[1] *t*-statistics were in parentheses.
[2] Marginal effects calculated at sample means. Marginal effects in terms of elasticities in brackets.
[3] Cattle purchased within 100 miles of packer.
[4] Cattle purchased between 100 and 300 miles of packer.
*Not statistically significant at the 0.05 level.

of 0.69% in the probability of using forward contracts and a 0.10% increase in the probability of procurement through marketing agreements. Further, a 1% increase in *slaughter capacity* results in a decrease of 1.34% in the probability that the cattle procured are packer fed and a 0.01% decrease in the probability of procurement through spot markets. That is, given an increase in slaughter capacity, packers are less likely to use the packer fed method of procuring cattle and more likely to use forward contracting with little impact on the likelihood of using other procurement methods.

The marginal effects computed for capacity utilization indicate that an 1% increase in capacity utilization results in a 1.63% decrease in the probability of packer fed procurement, a 0.61% increase in probability that cattle are procured through marketing agreements, and a 0.49% increase in probability that cattle are procured

Table 6. Estimated Coefficients and Marginal Effects in the Multinomial Logit Model for Pricing Methods Over All Firms and Regions

	Estimated Coefficients[1]		Marginal Effects[2]		
RHS variable	B1	B2	Carcass Weight	Formula	Live Weight
Capacity	0.0013	0.0033	0.0002	0.0001	−0.0004
	(16.37)	(24.74)	[0.1715]	[0.6994]	[−0.2062]
Capacity Utilization	0.3776	−2.2600	0.1460	−0.1405	−0.0055
	(8.69)	(−34.18)	[0.1638]	[−1.0122]	[−0.0046]
Output Price	−0.9107	2.5834	−0.2816	0.1724	0.1082
	(−25.50)	(45.41)	[−0.8958]	[3.5218]	[0.2556]
Number of Head	−0.0026	−0.0063	−0.0004	−0.0003	0.0007
	(−40.69)	(−52.67)	[−0.1394]	[−0.5810]	(0.1691]
Average Weight	0.0035	0.0023	0.0007	0.00004	−0.0008
	(52.79)	(22.72)	[2.3310]	[0.9176]	[−1.8197]
Regional HHI	0.00003	−0.0001	0.000010	−0.000004	−0.000005
	(6.75)	(−6.57)	[0.0945]	[−0.2779]	[−0.0377]
Elapsed Days	0.0042	−0.0108	0.0012	−0.0007	−0.0005
	(8.19)	(−16.54)	[0.0394]	[−0.1459]	[−0.0123]
Quarter 1	0.3937	−0.1538	0.0980	−0.0186	−0.0794
	(24.26)	(−6.09)			
Quarter 2	0.1467	0.1077	0.0324	0.0026	−0.0351
	(9.13)	(4.44)			
Quarter 3	−0.0316	0.0838	−0.0096	0.0056	0.0039
	(−2.04)	(3.44)			
Dairy	0.6594	−0.9738	0.1819	−0.0727	−0.1091
	(12.21)	(−15.68)			
Fed Holstein	0.1574	1.6676	−0.0033	0.0929	−0.0896
	(3.09)	(32.17)			
Heifers	0.4951	0.3080	0.1110	0.0057	−0.1167
	(34.89)	(14.54)			
Mixed	−0.0365*	−3.5256	0.0780	−0.2038	0.1257
	(−1.57)	(−31.65)			
D100[3]	−0.2040	−0.5734	−0.0347	−0.0282	0.0630
	(−13.13)	(−26.00)			
D100/300[4]	−0.1235	−0.5599	−0.0158	−0.0294	0.0452
	(−7.71)	(−23.87)			
Yield Grade 1	−0.9415	−2.2730	−0.1695	−0.1088	0.2783
	(−35.75)	(−35.66)			
Yield Grades 3, 4, 5	−0.2233	−0.3667	−0.0444	−0.0157	0.0602
	(−18.92)	(−20.41)			
Select	0.0599	−0.0661	0.0159	−0.0053	−0.0106
	(4.61)	(−3.27)			
Forward Contracts	2.5027	4.3705	0.4918	0.1921	−0.6840
	(42.06)	(65.40)			
Packer Fed	0.6831	0.9683	0.1397	0.0394	−0.1792
	(20.93)	(20.54)			
Marketing Agreements	3.0680	7.2759	0.5557	0.3469	−0.9027
	(29.96)	(72.43)			
Constant	−3.7489	−6.0282			
	(−36.62)	(−37.61)			

[1] *t*-statistics were in parentheses.
[2] Marginal effects were calculated at the sample means. Marginal effects in terms of elasticities were in brackets.
[3] Cattle purchased within 100 miles of packer.
[4] Cattle purchased between 100 and 300 miles of packer.
*Not statistically significant at the 0.05 level.

through forward contracts. Marginal effects for the spot market with respect to changes in capacity utilization are relatively small.

At the same time, a 1% increase in the *number of head in the procured lot* of cattle increases the probability of using forward contracts, packer fed arrangements, and marketing agreements by 0.17%, 0.78%, and 0.09%, respectively, but reduces the probability of using the spot market to procure cattle by 0.02%. On the other hand, a 1%

increase in the *average weight of the procured lot* reduces the probability of using packer fed arrangements and marketing agreements by 2.34% and 3.79%, respectively, but increases the probability of using the spot market by 0.32% and forward contracts by 0.81%.

A 1% increase in *regional firm concentration* (as measured by the RHHI) raises the probability of using packer fed arrangements by 3.18% but results in a 0.32%, 0.23%, and 0.01% decrease in the probability of using forward contracts, marketing agreements, and the spot market, respectively.

A 1% increase in the *output price of beef* increases the probability of procurement through packer fed arrangements and marketing agreements by 2.06% and 0.55%, respectively, but decreases the probability of procurement through forward contracting by 1.82%. The probability of using the spot market is almost unresponsive to changes in the output price of beef.

Increasing the *number of days between purchase and slaughter* of cattle (i.e., the elapsed number of days) decreases the probability of using the spot market but increases the probability of using all other procurement methods. As expected, this finding conforms to trading tradition or convention.

Seasonality also affects the probability of the selection of a given procurement method. Compared to the October 1992 to December 1992 period (the base period), the probability of using forward contracts to procure cattle is higher for the January 1993 to April 1993 (Q1) period and the April 1992 to June 1992 (Q2) period, but lower for the July 1992 to September 1992 (Q3) period. This finding is in agreement with previous studies wherein April and June are typically the months with more forward contracting. The probability of using marketing agreements and packer fed arrangements, as compared to the base period, is higher for the Q3 period but lower for the Q1 and Q2 periods. Finally, relative to the base period, the probability of using the spot market, *ceteris paribus,* is higher for the Q1, Q2, and Q3 periods.

The *type of cattle* procured also affects the probabilities of choosing a method of procurement. The spot market is more likely to be used for lots of cattle that are predominantly heifers or mixed cattle than for lots of just steers, but less likely to be used for lots that are predominantly dairy cattle or fed Holsteins. Forward contracting is more likely to be used for lots of dairy cattle and heifers than for lots of steers, but less likely to be used for lots of the other types of cattles (fed Holsteins, and mixed). Lots of dairy cattle procured are more likely to be packer fed than lots of steers, while lots of fed Holsteins, heifers, and mixed cattle are less likely to be packer fed. Marketing arrangements are more likely to be used to procure lots of fed Holsteins relative to lots of steers and are less likely to be used to procure lots of heifers, dairy cattle, and mixed cattle. Again, the findings of the model confirm traditional practice.

The empirical results also indicate that the *distance of the seller from the plant* affects the choice of procurement method. If procurement occurs within 300 miles of the packing plant, the probability of using either packer fed arrangements or marketing agreements rises while the probability of using forward contracting falls as compared to procurement outside a 300-mile radius of the plant. In other words, the procurement of cattle within 300 miles of the plant is more likely to be done by either packer fed arrangements or marketing agreements and is less likely to be done through forward contracting than is the case for procurement of cattle from sellers more than 300 miles from the plant. The effects of distance on the probability of using the spot market are mixed with a slightly lower probability associated with shorter distance (i.e., within 100 miles of the packer). The largest effects on choice of procurement among the quality variables are associated with the yield grade 1 (YG1) dummy variable. The probability of using the spot market and forward contracts increases with YG1, while the probability of using packer fed arrangements or marketing agreements decreases with increases in YG1.

Pricing Methods

The estimated coefficients and the associated marginal effects from the multinomial logit models corresponding to lot pricing methods across all firms and regions are provided in table 6. In this model, 68 of the 69 estimated coefficients are found to be statistically different from zero. Again, using equation (1) and the estimated coefficients (table 6), the probabilities of lot pricing method choice across all packers at the sample means of the RHS variables are calculated as: (1) 0.40 for carcass weight pricing, (2) 0.06 for formula pricing; and (3) 0.54 for liveweight pricing. In other words, there is a 93% probability that any given lot of cattle included in the transactions data set is priced on either a liveweight or carcass weight basis. Those two pricing methods accounted for roughly 80% of the transactions in the transactions data set (see table 2). On the other hand, there is a 6.18% probability that any given lot is priced using formula pricing.

The calculated marginal effects indicate that unit changes in RHS variables affect the probabilities

of using liveweight pricing and carcass weight pricing in opposite directions. Changes in factors that positively affect the probability of choosing liveweight as the pricing method negatively affect the probability of choosing carcass weight as the pricing method and vice versa.

An examination of the marginal effects elasticities for continuous variables indicates that a 1% increase in *slaughter capacity* leads to 0.17% and 0.70% increases in the probability of pricing cattle lots on a carcass weight and formula basis (Table 6), respectively, but a 0.21% decline in the probability of pricing lots on a liveweight basis. A 1% increase *in capacity utilization* leads to a 0.01% and 1.01% decrease in the probability of using formula and liveweight pricing but a 0.16% increase in the probability of using carcass weight pricing. A 1% increase in the *number of head per lot* increases the probability of pricing on a liveweight basis by 0.17% but decreases the probabilities of pricing on any other basis. According to the marginal effects elasticities, a 1% increase in the *average weight of the lot* increases the probability of pricing on a carcass weight basis and formula basis by 2.33% and 0.92%, respectively, while decreasing the probability of pricing on a liveweight basis by 1.82%.

A 1% increase in *regional firm concentration* increases the probability of pricing on a carcass weight basis by 0.09% but decreases the probability of pricing on a liveweight and formula basis by 0.04% and 0.28%, respectively. Increases in the *output price of beef* increase the probability of using all pricing methods except the carcass weight pricing method.

Probabilities of using all pricing methods, except carcass weight, decline as *elapsed time between purchase and slaughter* increases. *Seasonality* plays a role in the probability of selecting a particular pricing method. Relative to the base period (October to December 1992), the probability of pricing on a carcass weight basis is higher in the first six months of the year. The reverse is true for the liveweight pricing method. As compared to the base period, the probability of selecting the formula method is higher in the April to September 1992 period but is lower in the January to March period.

Cattle type also influences the probabilities of lot pricing method choice. Relative to the base case (i.e., lots of predominantly steers), the probability of choosing the carcass weight pricing method is higher but the probability of choosing any other pricing method is lower when the lots are predominantly dairy cattle. For lots that are mostly fed Holsteins, the probability of pricing on carcass weight or a liveweight bases is lower compared to the base case but is higher for formula pricing. For lots of mostly heifers, the probability of pricing on a liveweight basis is lower compared to the base case but is higher for all other pricing methods. For lots of mixed cattle, the probability of pricing on either a carcass weight or liveweight basis is higher than the base case but is lower for formula pricing.

The *yield grade* and *quality grade* of the lots also affect the choice of pricing method. The probabilities of choosing the carcass weight and the formula pricing methods are lower for lots of yield grade 1 and yield grade 3 through yield grade 5 cattle as compared to lots of yield grade 2 cattle (the base case). The opposite is true for liveweight pricing. The probability of choosing liveweight or formula pricing methods is lower for select quality grade cattle than choice quality grade cattle. The probability of choosing carcass weight pricing is higher.

Considering the *distance between the seller and the packer,* lots of cattle from sellers within 300 miles are less likely to be priced on a carcass weight and formula basis than cattle from sellers further than 300 miles from the packer. At the same time, however, lots of cattle from within 300 miles of the packer are more likely to be priced on a liveweight basis than lots from more distant sellers.

The *procurement method* selected clearly affects the probability of selecting a given pricing method. As compared to procurement through the spot market (the base case), the selection of forward contracting tends to increase the probability of selecting carcass weight and formula as the pricing methods but reduces the probability of selecting liveweight as the pricing method. This same result is true concerning the selection of packer fed arrangements and marketing agreements. These results, with the exception of the relationship between the packer fed procurement method and liveweight pricing method, are consistent with the actual pattern of procurement and pricing methods exhibited in the transactions data (see figure 1).

Predictive Ability of the Procurement and Pricing Models Across All Regions and Firms

To examine the predictive ability of the two models across all firms and regions, a prediction-success table is constructed as described in the methodology section for both procurement and pricing methods (tables 7 and 8). For procurement methods, the multinomial logit model correctly classifies nearly 87% of all 182,007 transactions. This success in classification is unequivocally the

Table 7. Prediction-Success Table: Procurement Methods Model Over All Firms and Regions

Actual Procurement Methods	Procurement Method Predictions: Forward Contract	Packer Fed	Marketing Agreement	Spot Market	Total	% Correct Classification
Forward Contract	10,750	159	5	2,792	13,706	78.4
Packer Fed	274	440	0	4,721	5,435	8.1
Marketing Agreement	217	49	54	15,214	15,534	0.3
Spot Market	67	536	23	146,706	147,332	99.6
Total	11,308	1,184	82	169,433	182,007	86.8

result of the ability of the model to correctly predict procurement transactions conducted through the spot market and by forward contracting. The model correctly predicted over 78% of those lots procured through forward contracting and nearly 100% of those procured through the spot market. As a predictive device, the model does extremely well in predicting the selection of the forward contract and spot market procurement methods.

The capability of the multinomial logit model to correctly classify procurement by packer fed arrangements and by marketing agreements, however, clearly is limited. This result may be due to the fact that these latter procurement methods may be sensitive to factors other than those specified in the model, e.g., weather, tradition, etc., many of which may not be represented in the transactions data.

The pricing method multinomial logit model correctly classifies about 60% of the set of transactions as to pricing methods. This success is largely attributable to the ability of the model to correctly predict the transactions which used the liveweight pricing method. The model correctly classified 80% of the lots using liveweight pricing but only 43% and 51% of the lots using carcass weight and formula pricing methods, respectively.

Limitations

The main limitation of this study involves the assumption that procurement and pricing decisions were not made simultaneously. Several attempts were made to investigate the sensitivity of the analysis to this assumption by considering jointly determined procurement and pricing decisions. Four procurement methods (spot market, marketing agreements, forward contracts, and packer fed arrangements) were combined with two classes of pricing methods: (1) pricing by weight (liveweight and carcass weight pricing methods) and (2) pricing by formula. Thus, the dependent variable of the multinomial logit model for the analysis of jointly determined procurement and pricing methods consisted of eight possible choices. The RHS variables were the same as those used in the procurement method choice analysis discussed previously. However, the nonlinear estimation procedure using LIMDEP failed to achieve convergence, predominantly due to the fact that one of the eight choices (liveweight pricing and spot market procurement) was associated with nearly 75% of the observations, dominating the other seven choices.

Another limitation deals with the possibility of misspecification bias in the procurement and pricing models. Data on factors such as management choices, weather, and tradition were not available. Consequently, the possibility exists that differences in procurement and pricing practices attributed to the explanatory variables in the models also may be due to management practices. Thus, because of the omission of particular factors due to data limitations, indeed there may be some confounding of the results.

Table 8. Prediction-Success Table: Pricing Methods Over All Firms and Regions

Actual Pricing Methods	Pricing Method Predictions: Carcass Weight	Formula	Live Weight	Total	% Correct Classifications
Carcass Weight	29,433	2,250	37,351	69,034	42.6
Formula	5,904	16,742	10,246	32,892	50.9
Liveweight	14,754	1,052	64,275	80,081	80.3
Total	50,091	20,041	111,872	182,007	60.7

Conclusions

The empirical results confirm that a large number of factors play a significant role in the determination of the methods of procurement and pricing chosen by packers for the cattle lots they purchase. The method chosen by packers to procure fed cattle was found to affect the probability that a given pricing method will be chosen. Procurement through the spot market was found to increase the tendency to use liveweight as the pricing method while procurement through forward contracting, packer fed cattle, and/or marketing agreements was found to increase the probability that packers will choose the carcass weight and formula pricing methods to price cattle.

Increases in slaughter capacity tend to increase the use of forward contracts but decrease the use of packer feeding as cattle procurement methods. An increase in regional concentration, as measured by the regional Herfindahl-Hirschman Index (RHHI), however, tends to increase the use of packer feeding but to reduce the use of all other procurement methods. So, increases in slaughter capacity and regional concentration give rise to different procurement methods.

As regional concentration increases (as measured by the RHHI), packers tend to choose the carcass weight pricing methods. With increases in slaughter capacity (an indicator for size economies), packers tend to gravitate toward pricing on carcass weight and formula bases. So, with increases in slaughter capacity and regional concentration, we may expect to see more of the carcass weight pricing method.

Moreover, an increase in wholesale beef demand, as reflected by an increase in the output price of beef, tends to reduce the choice of forward contracts as the procurement method and to increase the choice of marketing agreements and packer feeding. At the same time, as the output price rises, packers tend to move toward formula-based pricing methods or liveweight pricing. Carcass weight as a pricing method was inversely related to increases in wholesale beef demand.

Also, cattle procured from within 300 miles of packing plants were likely to be either packer fed cattle or were procured through a marketing arrangement. Procurement of cattle outside a radius of 300 miles of the packing plants is more likely to be done through forward contacts and the use of the spot market. Also, lots of cattle from sellers within 300 miles were less likely to be priced on formula or carcass weight bases.

Too, the probability of choosing to procure through the spot market and forward contracts increases with lots that were predominantly yield grade 1 relative to those that were predominantly yield grade 2 while the probability of choosing packer fed arrangements or marketing agreements decreases. The probability of choosing to procure through forward contracting, packer fed arrangements, and the spot market rises with lots that were predominantly yield grade 3 or higher as compared to those that were predominantly yield grade 2, while the probability of choosing marketing agreements declines with respect to this yield grade comparison. In lots that were graded select, the probability of choosing packer fed arrangements and the spot market increases, but the probability of using forward contracts or marketing agreements declines. For cattle yield grade 2, packers tend to use the carcass weight and formula pricing methods. They move away from the liveweight pricing method under these yield grade conditions. For prime or choice cattle, packers tend to use liveweight and formula pricing methods. Finally, changes in factors that positively affect the probability of choosing liveweight as the pricing method negatively affect the probability of choosing carcass weight as the pricing method and vice versa.

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