Concentration In Beef Packing and Slaughter Cattle Pricing

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Using unique data from a pre-mandatory price-reporting period we empirically investigate the effects of beef packer concentration and size efficiencies, packer procurement and pricing methods, and other market variables and quality characteristics on the prices paid by packers for slaughter cattle. We find that packers pay less for fed cattle in more concentrated regions. However, we find that concentration is only one of numerous market factors determining fed-cattle prices and is less important than many. Quality variables controlled by sellers, such as cattle type, are more important in determining the price paid by packers than packer concentration, size economies, procurement methods, or other variables outside seller control. This analysis then offers a set of hypotheses to consider in analyses of the beef packing industry from the post-mandatory price-reporting period.

Although myriad forces affect prices in any market, researchers, policy makers, and participants associated with slaughter cattle markets have been particularly concerned over the years about the effects of growing concentration and contract procurement methods commonly used in the beef packing industry. After several decades of relatively low concentration, mergers and acquisitions in beef packing pushed the industry four-firm concentration ratio from 36 percent in 1980 to 72 percent in 1990 and to 81 percent in 2000, where it has remained through 2007, the most recent reported period (USDA 2008). Because of limited shipping distances of fed-cattle, buyer concentration in local geographic areas often exceeds national concentration. Many cattle raisers and feeders have come to believe that packers have an unfair advantage in cattle transactions resulting from both high buyer concentration and asymmetric information. Packers buy cattle daily and have direct contact with retailers, giving them access to information about current and future demand conditions that sellers must often guess about. Perhaps most importantly from the sellers' point of view, until recently packers often procured cattle under contracts that forbade disclosure of price and other contract terms, leading to asymmetric information among market participants and the possibility of monopsony market power exertion by packers.

Growing concerns among cattle sellers that a few large packers control slaughter cattle markets and procurement practices and that their control may be affecting prices paid to sellers has prompted periodic calls by producers for greater federal control and oversight of packer activities. The government response to these concerns has included numerous studies, hearings, and the introduction and passage of new laws. One such response, the Livestock Mandatory Price Reporting Act of 1999 (7 U.S.C. § 1635 *et seq.*), requires packers slaughtering at least 125,000 head of cattle, 100,000 swine, or 75,000 lambs annually to report the details of all purchases and sales of livestock and meat products twice daily. Before mandatory reporting, only spot market prices were reported. As a result, government published market price reports were based on only a portion of the total transaction volume. Proponents of the new law argued mandatory price reporting was needed to rectify information disparities between cattle sellers and packers resulting from contract purchases of livestock that bypassed traditional spot markets.

Several past empirical analyses have found limited support for cattle seller claims that in-

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creased concentration may be allowing packers to exert market power in fed cattle markets (see, for example, Azzam and Schroeter 1991; Stiegert, Azzam, and Brorsen 1993; Koontz and Garcia 1997). The recent congressionally mandated analysis of packer ownership concluded that eliminating all packer procurement methods except cash or spot markets would reduce "cattle prices, quantities, and producer and consumer surplus in almost all sectors of the industry because of additional processing costs and reductions in beef quality" (RTI 2007, p. ES-9). Packer concentration alone does not guarantee that fed-cattle prices are being manipulated by beef packers (Stiegert, Azzam, and Brorsen 1993; Azzam 1996). Indeed, concentration may result from the need to gain economies of size in order for packers to remain competitive (Azzam and Schroeter 1995). In addition, the effects of concentration on prices may be small compared to the effects of the many other factors impinging on fed cattle markets.

Isolating and measuring the relative effects of concentration and other factors on fed-cattle prices is complicated. Forces range from traditional market factors like production costs and capacity to contract design of pricing and procurement methods and competitive conditions that are influenced by market structure (Schroeder et al. 1993). Furthermore, slaughter cattle are not homogeneous. Specific lots of fed cattle vary by type, breed, weight, and quality and yield grade. Data that include such information for specific cattle lots have not been available publicly, so research on slaughter cattle pricing has been difficult at best.

This article develops a hedonic price model that incorporates features of a farm-to-wholesale market margin analysis to quantify relationships between the prices paid by packers for fed cattle and market and quality characteristics associated with specific slaughter cattle lots. Previous applications of the hedonic price modeling approach have presumed that firms operate within the confines of perfectly competitive markets. This analysis extends the hedonic framework to allow firms to operate within possibly imperfectly competitive markets. To conduct the empirical analysis, we use daily transactions records and costs and returns data from the 43 largest steer and heifer beef packing plants collected by the Grains Inspection, Packers and Stockyards Administration (GIPSA) of the U.S. Department of Agriculture (USDA) as part of a Congressionally mandated study to determine the effects of concentration in the meat packing industry (USDA 1996). The data include information on nearly all steer and heifer purchases within the sample period regardless of pricing and procurement methods. While these data are from the pre-mandatory price reporting period, our analysis ultimately offers a set of hypotheses to consider in analyses of the beef packing industry from the post-mandatory price reporting period.

No data set currently exists that allows this comparative examination. Indeed the transactions data consisting of market and quality characteristics for 200,616 lots of fed cattle slaughtered by 43 steer and heifer packing plants in the United States covering the period April 5, 1992 to April 3, 1993 are not reflective of current conditions. While the analysis may be dated, nevertheless, from a methodological point of view, our analysis makes a contribution in better understanding pricing behavior in the beef packing industry.

Our analysis addresses three related questions. First, we investigate how concentration in beef packing and the associated increase in size efficiencies of large packing firms affect the prices packers pay cattle sellers. Second, we address the question of whether "packers' direct ownership and feeding of cattle for slaughter and their procurement of slaughter supplies through forward contracts . . . decreased prices paid to cattle producers." Third, we rank and compare the economic importance of competing explanatory factors on prices paid by packers, including the effects on prices of (1) packer concentration and size economies, (2) procurement and pricing methods used by packers, (3) other market factors, and (4) quality characteristics of the cattle purchased such as average weight and yield grade. Answers to these questions should help enlighten future debates on the need for additional government intervention.

Following development of the farm-to-market hedonic price model, descriptive statistics of the data are presented. Specific hypotheses relating to factors affecting the price of fed cattle paid by packers are considered next, followed by a discussion of empirical results. Finally, conclusions and implications for issues in slaughter cattle pricing are discussed.

A Hedonic Price Model with Imperfectly Competitive Markets

Hedonic price models are widely used to determine implicit values associated with specific utility-bearing attributes of characteristics embodied within a differentiated product (e.g., Rosen 1974; Lucas 1975; Ladd and Suvanant 1976; Brown and Rosen 1982; Parker and Zilberman 1993). These models are useful for analyzing product heterogeneity issues such as product differentiation, quality, grades, and standards. Previous applications of the hedonic technique generally have focused on determining the economic value associated with specific identifiable utility-bearing product attributes. Using the hedonic approach, products are viewed as bundles of characteristics so that products in a particular class are completely described by a vector of product attributes (e.g., Rosen 1974; Lucas 1975). Thus transactions are equivalent to tied sales so that a price function arises linking the observed market price of product i (P_i) to a vector of intrinsic quality characteristics (z_{ij}), that is, $P_i = P(z_{i1}, z_{i2}, \ldots, z_{iJ}, \varepsilon_i)$, where ε_i is a disturbance term. Lucas (1975) shows that such a price function can be justified on three grounds: (1) buyers efficiently select commodities based on prices and characteristics; (2) cost-minimizing competitive firms produce differentiated products with access to either different factor prices, cost functions, or non-homothetic cost functions and different scales of production; or (3) market prices are at equilibrium levels as a result of the market interactions between buyers and sellers in perfectly competitive markets. Under any of these three conditions, product prices can be regressed on observed product characteristics relating to quality or other product features and on buyer characteristics to obtain estimated values associated with each characteristic.

In concentrated markets competitive pricing may not exist, so that Lucas' price function must be modified. The relationship between prices paid by packers for cattle and the characteristics of cattle purchased can be formalized. Packers purchase fed cattle from cattle sellers and transform them into beef and beef products which they sell in the wholesale market. Assume that cattle in a particular region are supplied by competitive price-taking cattle sellers and that each lot sold is characterized by a vector of quality factors unique to that lot. Assume further that producing high-quality fed cattle is costly, so that various quality factors are associated with different production costs. Costly transaction characteristics important to buyers may include procurement and pricing methods, since contract terms effect buyer transactions costs and risk exposure. Establishment of product quality and transaction characteristics at the fed cattle level implies that the price a processor is willing to pay for fed cattle depends on those characteristics.

Under these assumptions, the price paid by a given processor (i) for a given lot of cattle (j) can be written as the sum of two components: (1) the average market price in the region (w) and (2) discounts and/or premiums for quality characteristics associated with each lot j purchased by processor i ($d_{ij} < 0$). The aggregate price-dependent supply of fed cattle in a given region can be written as $w = w(x)$, where w is an unobserved "average" regional market price, w(x) represents the price-dependent supply of the fed cattle, and x is the total regional quantity of fed cattle supplied.

Each lot purchased by a processor in the region is characterized by a vector of intrinsic quality and transaction factors (z_{ij}) for which premiums may be paid or discounts taken: $d_{ij} = g_i(z_{ij})$. Hence the price of any particular lot purchased by a given processor in a given region can be written as

$$(1) \qquad w_{ij} = w + d_{ij} = w(x) + g_i(z_{ij}),$$

where w_{ij} is price/lb for lot j of fed cattle purchased by processor i in a given region.

Following Durham and Sexton (1992), the slaughter cattle processing sector is assumed to be characterized by a quasi-fixed proportions technology that allows no substitution between fed cattle (x) and a vector of non-farm inputs (F) that includes both variable and quasi-fixed inputs. Processor i's production function is given by $q_i = \min [\lambda x_i, h(F_i)]$, where q_i is that processor's output of meat and meat products, x_i is quantity of fed cattle used by the processor, $h(F_i)$ represents the technology associated with variable and quasi-fixed inputs, F_i is a vector of the processor's use of variable and quasi-fixed inputs, and λ is the fed cattle-to-meat product conversion ratio. Given this production technology, cost minimization requires $q_i = \lambda x_i$.

Although the processing industry is concentrated and can potentially exert monopsony market power

in the fed cattle market, processing firms must compete nationally and internationally in product sales. Hence while each processor assumes the wholesale price is fixed, the regional fed-cattle price is assumed to be affected by each firm's purchases through the regional supply function. Processor i's profit (π) function is then given by

$$(2)\quad x_i = \sum_j \left\{ P\lambda x_{ij} - \left[w\left(\sum_j x_{ij} + x_{\sim i}\right) + g_i(z_{ij}) \right] x_{ij} - c_i(v; k_i) x_{ij} \right\},$$

where P is wholesale output beef price, x_{ij} represents processor i's purchases of fed cattle of lot j, $x_{\sim i}$ represents fed-cattle purchases by all other processors in the region, and $c_i(v; k_i)$ is processor i's restricted unit cost function for costs other than fed cattle and is a function of variable input prices (v) and quantities of quasi-fixed inputs (k_i) used by processor i. Profit maximization results in the following first-order condition:

$$(3)\quad \frac{P\lambda}{w} - \frac{s_i}{\varepsilon} - 1 - \frac{g_i(z_{ij})}{w} - \frac{c_i(v; k_i}{w} = 0$$

where s_i is processor i's regional market share and ε is the price elasticity of supply in the region. Imposing the Cournot conjecture, $\partial x_{\sim i}/\partial x_{ij} = 0$, using the definition in Equation 1, dividing both sides of the equality by w, and summing over lots (j), processor i's optimal equilibrium condition over all lots can be written as

$$(3')\quad \frac{\partial \pi_i}{\partial x_{ij}} = P\lambda - \frac{\partial w}{\partial x}\left(1 + \frac{\partial x_{\sim i}}{\partial x_{ij}}\right) x_{ij} - w_{ij} - c_i(v; k_i) = 0$$

Multiplying by w and aggregating over all processors in the region using each firm's weighted average share results in the following market equilibrium condition over all transactions:

$$(4)\quad P\lambda - RHHI \cdot \frac{w}{\varepsilon} - w - \overline{g(z_{ij})} - \overline{c(v; k_i)} = 0\ ,$$

where RHHI = $\sum_{i=1}^{I_r} s_i^2$ is the regional Herfindahl-Hirschmann index; I_r is the number of packers in region r; s_i is processor i's regional market share; $\overline{g(z_{ij})}$ is the weighted average premium/discount over all transactions in the region; and $\overline{c(v; k_i)}$ is the weighted average unit cost in the region for all inputs except fed cattle. Equation 4 gives the relationship between average wholesale meat price and average fed-cattle price within a region and is the hedonic price model over all processors and lots of cattle purchased in a given region. For purchases of specific lots of fed cattle by specific processors, Equation 4 can be rewritten as

$$(4')\quad w_{ij} = P\lambda - RHHI \cdot \frac{w}{\varepsilon} - w - g(z_{ij}) - c(v; k_i)\ ,$$

which gives an hedonic price model for effects of quality characteristics and competitive market conditions on the price paid by a given processor for a specific fed-cattle lot within a specific region.

Description of the Data

GIPSA provided both transactions and weekly plant-level packer costs and returns data for this analysis. The transactions data include observations on market and quality characteristics for 200,616 lots of fed cattle slaughtered by the largest 43 steer and heifer beef packing plants between April 5, 1992 and April 3, 1993. Transactions-level quality characteristics include the predominant cattle type in each lot, USDA quality and yield grades, number of head per lot, and average weight per head in each lot. Additional information for each transaction includes point of purchase, distance from seller to packer, and market information for the procurement and pricing methods used.[1]

Cost and returns data for each packer include fed-cattle price, beef output price, plant capacity, various costs, and data used to compute the RHHI. These data come from the GIPSA Beef Packer Costs and Returns Survey (BPCRS) and include weekly and monthly observations on costs and quantities

[1] See Williams et al. (1996), especially Sections 1 and 2, for a detailed discussion of the data. This technical report is one of six comprising the GIPSA Concentration in the Red Meat Packing Industry study (USDA 1996). All data were required to be returned to GIPSA at the conclusion of the study owing to their highly proprietary nature.

for most input and output categories for the same 43 packing plants over the same period (April 5, 1992 to April 3, 1993).[2] The data are merged on a plant by plant basis with the transactions data to create the complete data set for 39 plants.[3] These weekly data are merged with transaction data to obtain a full set of attributes associated with each transaction. The final transactions data set includes 182,007 lots of fed cattle slaughtered by 39 steer and heifer packing plants during the April 5, 1992 and April 3, 1993 interval, representing 91 percent of the observations contained in the original data set. While the data are representative of the situation in the pre-mandatory price-reporting period, no current data exist in the post-mandatory price-reporting period. Nevertheless, our analysis is useful from a methodological point of view and in providing a set of hypotheses ultimately to be tested in the post-mandatory price-reporting period.

Cattle and Meat Prices

Descriptive statistics of the variables used in the empirical model are provided in Table 1. The representative (average) lot contains about 120 head of cattle with an average liveweight per head of about 1,170 lb. The fed-cattle price paid by packers is defined as the total liveweight cost/lb of cattle delivered to the packer, including transportation, any commissions paid, and feed charged to the packer by the seller. On average, packers paid $0.75/lb for fed cattle.

The output price is defined as 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. The output-price information comes from the BPCRS and is recorded for each packing plant by week. The weighted average revenue from beef sales over the period is $1.26/lb.

Plant Capacity

Each plant's slaughter capacity, measured as number of head slaughtered per hour, also comes from the BPCRS. Only two observations on slaughter capacity are available—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 plant capacity is different on the two dates, the maximum of the two capacity observations is used in our analysis. On average over all plants, the maximum slaughter capacity is about 280 head per hour.

Regional Market Definition and Concentration

Ward (1990) found that most cattle are purchased for a specific plant from within a 100-mile radius of that facility, whether the owning firm has 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 categories (distance from seller to packer) are established: (1) less than 100 miles; (2) between 100 and 300 miles; and (3) greater than 300 miles. Using packer and seller locations as provided in the transactions data, roughly 53 percent of the cattle are purchased by packers from sellers within 100 miles of the plant, 32 percent from sellers between 100 and 300 miles from the plant, and the remaining 15 percent from sellers over 300 miles from the plant.

To facilitate the empirical analysis, regional cattle markets must be defined. Since transactions data include both buyer and seller identities and locations, physical cattle movements can be traced. Following Elzinga and Hogarty (1973) and Bresnahan and Reiss (1991), we use physical movements of goods from one location to another as the primary criterion to delineate the extent of a regional market. Historically, GIPSA has defined cattle procurement regions rather broadly to include: (1) North Atlantic, (2) East North Central, (3) West North Central, (4)

[2] See Section 1 of Williams et al. (1996) for a detailed discussion of the BPCRS data.

[3] The transactions data for four of the 43 plants are incomplete and are not included in the analysis. Also, missing and/or zero observations for market and quality characteristics are omitted. An additional 303 observations are considered to be outliers and deleted from the data set for several reasons: (1) 142 observations with output prices of $0.27/lb and 117 observations with output prices of $0.17/lb are deleted; (2) 29 observations for which the delivered liveweight price/lb of fed cattle is less than $0.40 or greater than $1.08 are deleted; and (3) 15 observations for which average weights per head are less than 800 lb or greater than 1,900 lb are deleted.

Table 1. Descriptive Statistics of Data Across All Regions and Packer Firms.

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 between purchase and slaughter (days)	12.34	30.04	0	240
Fed-cattle price paid by packers ($/lb)	0.75	0.04	0.41	1.07
Beef output price ($/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 (percent)	24.55	13.13	D	D
Regional firm Herfindahl-Hirschmann Index	3,865	1,185	2,610	10,000
Seasonality (percentage 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	NA	0	100
Distance from seller to packer (percentage 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	NA	0	100
Cattle type (percentage 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	0.4685	0	100
Steers	55.1	0.4685	0	100
Heifers	32.5	0.1400	0	100
Procurement method (percentage 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 (percentage 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

The number of observations for each variable is 182,007.
D denotes “deleted to avoid disclosure” and NA denotes “not applicable.”

South Plains, (5) Mountain, and (6) Pacific.[4] These regions were deemed too broad since GIPSA data used in this analysis reveal that most cattle are purchased within 300 miles of the plant where they are slaughtered. Smaller regional cattle procurement markets are therefore 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. Plants are placed in each procurement region using two criteria: (1) plant location and (2) plant procurement area. A plant is first assigned to the region in which it is located. Next, procurement patterns are examined. A plant purchasing a majority of cattle from a region outside its physical location is reassigned to a different region. For example, if a plant is located in Nebraska (Region 1) but purchases a majority of its cattle from Kansas sellers, the plant is reassigned to Region 3. If markets are "too close," movements of fed cattle across delineated regional markets will reduce the potential for market power exertion by packers in those markets. Hence insignificance of the RHHI in the empirical hedonic price equation may indicate either poorly defined regional market boundaries or lack of market power exertion.

Constructed using the previously defined regions, competition among packers varies by region. The number of meat packing firms included in a procurement region ranges from two to five. Ward (1990) found packers typically have two to four main competitors in their procurement market. Assuming equal market shares, the four-firm RHHI would be 2,500 and the two-firm RHHI would be 5,000. Consistent with Ward's observation, the mean RHHI computed from the GIPSA data is 3,865, indicating a high average concentration level.

Procurement and Pricing Methods

One way that quantity, quality, and price uncertainty can be reduced is through choice of procurement and pricing contract terms. Procurement methods include: forward contracting, packer fed/owned, marketing agreement, and spot market. By convention, spot-market or cash purchases are cattle procured directly from feedlots, public markets, or other sellers for delivery by sellers to buyers within two weeks of slaughter, and unusually within fewer days. Most often, spot sells are transacted through sealed bid auctions where buyers are invited to assess specific lots of cattle and enter sealed bids. Before mandatory price reporting, government price reports were based on spot market transactions only. In contrast, forward-contracted cattle are procured through contracts established at any time from placement of cattle on feed up to two weeks prior to slaughter. Forward contracts are used for reducing seller price risk but may increase buyer quality and volume uncertainty. Like spot-market purchases, cattle are generally procured through forward contracts on a lot-by-lot basis in anticipation of slaughter needs. Marketing agreements are long-term procurement arrangements (contracts) in which the packer agrees to purchase a specified number of cattle in a specified time frame. Marketing agreements generally provide purchasers with some degree of management decision authority. Finally, packer-fed/owned cattle are owned by the packer and fed either by custom (contract) feeders or by a feedlot owned and controlled by the packer.

Commonly used pricing methods include live-weight, carcass-weight, and formula pricing. Under live-weight pricing, payments are based on live weight of the lot prior to slaughter creating a degree of uncertainty about the actual value of the animal. In contrast, payments for carcass-weight priced livestock are based on dressed weight of a lot after slaughter. Formula pricing is based on a formula such as the packer's weekly average prices paid or on an average of two or more public price reports. Under formula pricing, payments may be based on either live or carcass weight of the lot.

About 81 percent of the cattle lots in the transactions data set are procured through the spot market. Only nine percent are procured through marketing agreements, eight percent through forward contracts, and three percent through packer-fed arrangements. Roughly 44 percent of the lots are priced on a liveweight basis, 38 percent on a carcass weight basis, and 18 percent on a formula basis. There is a high degree of correlation between procurement and pricing method. Most cattle procured through spot markets are purchased using live-weight pricing (53 percent) or carcass-weight pricing (37 percent). Most cattle procured through forward contracts are purchased using carcass-weight pric-

[4] See, for example, the tables of regional data in USDA (2006).

ing (73 percent) or formula pricing (21 percent). Most cattle procured through marketing agreements are purchased using formula pricing (91 percent) or carcass-weight pricing (eight percent). Finally, while choice of pricing method is somewhat arbitrary for packer-fed/owned cattle since procurement is an internal pricing decision, pricing methods for packer-fed cattle reflect the spot-market or cattle-procurement shares with most packer-fed cattle purchased through carcass-weight (45 percent) or live-weight (41 percent) methods.

Other Quality Characteristics

Beside average weight and lot size, other quality characteristics data include information concerning cattle type (dairy, fed Holsteins, steers, heifers, and mixed), yield grade, and quality grade. Dummy variables are used to account for qualitative attributes of the purchase lots such as cattle type. Lots with a majority of steers comprise 55 percent of the number of transactions while lots with a majority of heifers comprise nearly 33 percent. The remainder corresponds to lots with a majority of either dairy cattle, mixed cattle, or fed Holsteins.

Yield grades and quality grades for each lot are also represented though dummy variables. Two groups of variables are included to capture 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, (2) lots that are predominantly Yield Grade 2, and (3) lots that are predominantly Yield Grades 3, 4, and 5. The second group of quality variables is a series of dummy variables representing lots that are predominantly Prime, Choice, or Select.

Because the daily transactions occur over a full year (April 5, 1992 to April 3, 1993), fed-cattle prices may 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. About 23 percent of the cattle were slaughtered between January and April of 1993, 25 percent between April and June of 1992, 26 percent between July and September of 1992, and 26 percent between October and December of 1992.

Empirical Model

The empirical model given in Equation 4' is operationalized assuming λ and w/ε are unknown parameters, that unit cost $c_i(\bullet)$ is a function of maximum slaughter capacity, and that $g(z_{ij})$ is a linear function. In empirical applications of hedonic price models, Cropper, Deck, and McConnell (1988) generally find that a linear functional form induces least bias in measuring marginal prices of specific product attributes in both correctly specified and misspecified models. Given these assumptions, the farm-to-packer hedonic price equation is given as

$$(5)\quad w_{ij} = ß_0 + ß_1 P_i + ß_2 RHHI + ß_3 CAP_i + ß_4 HEAD_{ij} + ß_5 WGT_{ij} + \Sigma_m(ß_{6m} DIST_{mij}) + \Sigma_n(ß_{7n} SEAS_{nij}) + \Sigma_q(ß_{8h} TYPE_{qij}) + \Sigma_k(ß_{9k} YG_{kij}) + ß_{10} QGS_{ij} + \Sigma_l(ß_{11l} PROC_{lij}) + \Sigma_o(ß_{12o} PRIC_{oij}) + \varepsilon_{ij},$$

where j is a lot purchased by plant i and w_{ij} is the price per lb paid; P_i is weighted average revenue from beef sales during the week that lot j was purchased; RHHI is the regional Herfindahl-Hirschmann index; CAP_i is maximum slaughter capacity; $HEAD_{ij}$ is number of head in lot j; WGT_{ij} is average weight per head in lot j; $DIST_{mij}$ is a set of m = one to two dummy variables representing distance categories between the seller and the processor of a lot (1 = less than 100 miles; 2 = between 100 and 300 miles; base = over 300 miles); $SEAS_{nij}$ is a set of n = one to three dummy variables representing the quarters in which lot j is processed (1 = Quarter 1; 2 = Quarter 2; 3 = Quarter 3; base = Quarter 4); $TYPE_{qij}$ is a set of q = D,F,H,M dummy variables for five cattle types in lot j (D = dairy; H = heifers; H = fed Holsteins; M = mixed; base = steers); YG_{kij} is a set of k = one to two dummy variables for three predominant yield grade categories in lot j (1 = Yield Grade 1; 2 = Yield Grades 3, 4, or 5; base = Yield Grade 2); QGS is a dummy variable for the predominant quality grade "Select" in lot j (base = quality grade "Prime/Choice"); $PROC_{lij}$ is a set of dummy variables l = F,P,M for procurement method used i to purchase lot j (F = forward contract; P = packer-fed; M = marketing arrangement; base = spot market); and $PRIC_{oij}$ is a set of o = C,F dummy variables for pricing methods used i to purchase lot j (C = carcass weight; F = formula; base = liveweight).

Estimated parameters from Equation 5 provide

a measure of the "shadow" or marginal prices associated with each market and quality characteristic of the lot. Given the large number of cattle sellers, we assume that fed cattle are supplied by competitive price taking firms. Furthermore, since packers compete in national and international meat product markets, we assume that packers are competitive price takers in beef output markets. Given these conditions, unbiased model parameter estimates can be obtained using ordinary least squares (OLS) estimation because the data reflect micro-level purchases made by each packing plant.

Equation 5 is based on a number of specific hypotheses regarding market and quality factors that affect the fed-cattle price paid by packers. Considering market factors, we expect the fed-cattle price to be positively related to the beef output price since slaughter cattle demand is derived from wholesale beef demand. We expect the estimated coefficient associated with the RHHI to be negative since greater regional market concentration among packers is associated with greater potential for monopsony market power exertion.

Ceteris paribus, a positive relationship between slaughter capacity and the price of fed cattle is hypothesized since large packers may enjoy economies of size, resulting in higher profits that may be shared with cattle sellers. To keep unit costs low, packers must secure adequate fed-cattle supplies with desired characteristics to operate as close to full capacity as possible. As capacity rises, competition among packers for fed cattle in the region may intensify, forcing fed-cattle prices higher. As a plant gets larger, both capacity and regional concentration among firms tend to rise making the combined effect of increased slaughter capacity on the price of fed cattle paid by packers ambiguous (Azzam and Schroeter 1995).

To sort out the total or combined effect of increasing plant capacity on fed-cattle price, the RHHI can be redefined using the identity $x_i = UTIL_i \cdot CAP_i$ to establish plant i's share, where x_i is quantity of fed cattle purchased by plant i and $UTIL_i$ is plant i's capacity utilization:

$$(6)\quad RHHI = \sum_{i=1}^{I_r} \left(\frac{100 \cdot UTIL_i CAP_i}{\sum_{i=1}^{I_r} UTIL_i CAP_i} \right)^2 .$$

Assuming that capacity utilization remains constant for all plants, the total effect of a change in one plant's capacity on fed-cattle price can be found by substituting Equation 6 into Equation 5 and totally differentiating with respect to plant i's capacity. This expression is given by

$$(7)\quad \frac{dw_{ij}}{dCAP_i} = 2\beta_2 \cdot \left(\frac{S_i}{CAP_i} \right) \cdot \left[S_i - \frac{1}{100} \cdot RHHI \right] + \beta_3 .$$

An elasticity can easily be obtained from this expression by multiplying the total derivative by capacity and dividing by fed cattle cost per pound.[5]

Under competitive conditions, the price packers pay for fed cattle should be equal across all lots irrespective of point-of-origin, after adjustment for transportation costs. Spatial monopsony market power exertion by packers should be reflected in lower prices paid for fed cattle originating at points nearest to the respective plants. Alternatively, because cattle shipped over shorter distances should arrive at packers' gates in better condition than cattle shipped longer distances and because the transactions costs associated with purchasing cattle from more distant sellers may be higher, packers may be willing to pay higher prices for cattle from nearby sellers. Thus the price paid by packers for cattle from more distant sellers could plausibly be lower than that for cattle from sellers closer to the packer. It is not possible to discern the prevailing hypothesis *a priori*.

Packers use a variety of pricing and procurement practices to secure fed cattle. Among these are practices that have come to be known collectively as captive supply procurement and pricing, defined as packer feeding of cattle, forward contracting of cattle, and/or formula pricing of cattle (Ward 1990). Packer use of captive supply procurement and pricing methods represents a form of vertical integration in which the packer either directly or indirectly controls decisions made concerning fed cattle production and sale.

Captive supplies have two potential opposite effects on fed-cattle prices. First, cattle sellers are

[5] A reviewer pointed out that capacity utilization is more likely to fluctuate than actual capacity as plants adjust to supply and demand conditions in the marketplace. Hence capacity utilization is a short-run decision, while capacity is a longer-run decision.

subject to less market uncertainty since they have already established an output price before output is realized. If sellers are risk averse, they may be willing to accept a lower price for their cattle than might eventually be available by selling on the spot market. Second, captive supply pricing and procurement methods may allow packers to price discriminate by paying a higher price for captive supplies to contracting firms and a lower price to external firms. This practice can lead to a higher profit for the integrated packer-feeder firm (Love and Burton 1999; Xia and Sexton 2004).

Quality factors include average weight per head, quality and yield grades, cattle type, and number of head per lot. We expect average weight and the fed-cattle price paid to be negatively related since over-finished and heavy exotic cattle breeds are discounted by packers. We expect lots dominated by dairy cattle, fed Holsteins, mixed lots, and heifers to be discounted relative to steers (the base). We expect fed-cattle costs to reflect differences in yield and quality grades, quality characteristics of cattle that are actually measured. Predominantly Yield Grade 1 lots are expected to receive a premium and predominantly Yield Grade 3, 4, or 5 lots a discount vis-à-vis predominantly Yield Grade 2 lots (the base yield grade). Predominantly Select grade cattle lots are hypothesized to receive a discount vis-á-vis mostly Prime and/or Choice grade cattle lots (the base quality grade). Finally, given the transactions costs required to consolidate small lots across a number of small sellers, the larger the number of head in a lot, the higher the price packers will be willing to pay for fed cattle.

Results and Discussion

The OLS parameter estimates from the model are presented in Table 2 along with estimated elasticities for continuous explanatory variables evaluated at the means of the data. About 54 percent of the variation in the fed-cattle price across all firms and regions is explained by the model. The coefficients of all variables have the expected signs and, with one exception, are all statistically significant at the 0.01 level.

A somewhat surprising result is the consistently small elasticity estimates for continuous explanatory variables. One possible explanation is lack of variability in the largely cross-sectional transactions data used in this study. Because the data include only one year of information on packer transactions, variations in prices, regional concentration, and slaughter capacity are mainly due to cross-sectional differences. For example, the standard deviation in fed-cattle price is only $0.043/lb, with a mean of $0.754/lb. Observed variability would be higher over a longer period so that more fluctuations would result from shifts in supply and demand, allowing more accurate measurement of the magnitudes of the effects of changes in explanatory variables on fed-cattle price.

Effects of Concentration and Size Efficiencies

The small but highly significant parameter estimate associated with the regional firm Herfindahl index (RHHI) indicates that packers in more concentrated regions of the United States pay less for fed cattle than do packers in less concentrated regions. On average, a one percent increase in the RHHI leads to only a 0.011 percent decrease in the price packers pay for fed cattle. Moving from the least to the most concentrated region results in a reduction of $1.55/cwt in the price packers pay for fed cattle.

Although changes in price paid by packers for fed cattle are positively related to changes in slaughter capacity (CAP), as expected, the estimated elasticity from Equation 7 using mean values and estimated parameters indicates that a one percent increase in capacity yields a 0.021 percent increase in the fed-cattle price. However, raising slaughter capacity from one standard deviation below to one standard deviation above mean capacity increases the price paid by packers for fed cattle by $0.85/cwt.

Hence the savings associated with increased economies of scale due to capacity expansion appear to slightly outweigh the competition-reducing effects associated with greater market concentration. At least this appears true for the concentration levels that existed in 1992–93 in the United States and is consistent with the findings of Azzam and Schroeter (1995).

Effects of Captive Supply Procurement and Pricing Methods

According to our empirical estimates, packer-fed lots of cattle (PROCPF) and those purchased through forward contracting (PROCFC) cost

Table 2. Hedonic Price Model Estimates Across All U.S. Regions and Packer Firms.

RHS variable	Parameter estimate ($/lb)	*t*-ratio	Elasticity estimates
Constant	0.8310	698.71	
Market variables			
Regional Herfindahl Index (RHHI)	-0.0000021	-35.69	-0.0109
Capacity (CAP)	0.000057	59.63	0.0208
Output price (P)	0.0095	23.22	0.0158
Procurement methods:			
Forward contract (PROCFC)	-0.0174	-63.76	
Packer-fed (PROCPF)	-0.0057	-14.34	
Market agreement (PROCMA)	0.0054	17.99	
Pricing methods:			
Carcass weight (PRICC)	-0.0018	-5.00	
Formula (PRICF)	-0.0025	-17.07	
Quality variables			
Number of head (HEAD)	0.000021	29.97	0.0033
Average weight (WGT)	-0.000078	-100.34	-0.1217
DIST1	0.0019	11.06	
DIST21	-0.0007	-3.56	
Quarter 1 (SEAS1)	0.0373	196.55	
Quarter 2 (SEAS2)	-0.00014*	-0.74	
Quarter 3 (SEAS3)	-0.0184	-102.07	
Dairy (TYPED)	-0.0545	-148.26	
Fed Holsteins (TYPEF)	-0.0559	-119.63	
Heifers (TYPEH)	-0.0093	-56.25	
Mixed (TYPEM)	-0.0365	-126.40	
Yield Grade 1 (YG1)	0.0032	11.11	
Yield Grade 3, 4, or 5 (YG345)	-0.0015	-11.28	
Select (QGS)	-0.0011	-6.91	
R-square	0.5401		

Data used include 182,007 observations across all variables.
DIST1 and DIST2 represent cattle purchased within 100 miles and between 100 and 300 miles of packer, respectively.
* Estimates *not* statistically significant at the 0.05 level.

packers an estimated $0.57/cwt less and $1.74/cwt less, respectively, than lots purchased through spot markets (Table 2). On the other hand, packers pay $0.54/cwt more on average for fed-cattle lots purchased through a marketing agreement (PROCMA) than for lots purchased on the spot market. Note also that cattle lots priced on a formula basis (PRICF) or on a carcass weight basis (PRICC) cost packers less by $0.25/cwt and $0.18/cwt, respectively, than those priced on a liveweight basis. In other words, packers pay less for lots using procurement and pricing methods corresponding to captive supply behavior than for those lots procured through spot markets or priced on a liveweight basis.

Effects of Other Market and Quality Factors

If packers exert spatial market power in fed-cattle procurement, the prices they pay for cattle from nearby sellers might be expected to be lower than those for cattle purchased from more distant sellers. The empirical results, however, indicate that fed cattle purchased from sellers within 100 miles of the plant (DIST1) earn $0.19/cwt more than cattle purchased from sellers more than 300 miles away from the plant. Cattle purchased from sellers between 100 and 300 miles away from the plant (DIST2) cost packers $0.07/cwt less than cattle purchased from sellers more than 300 miles away. On average, therefore, packers do not appear to be exerting spatial monopsony market power on nearby cattle sellers. In fact, the positive sign on DIST1 in Table 2 indicates that packers pay a small premium for nearby cattle. This result is consistent with the alternative hypothesis that packers pay higher prices for cattle from nearby sellers because cattle shipped shorter distances arrive in better condition than those shipped longer distances and because of the higher transactions costs associated with purchasing cattle from more distant sellers.

Results also indicate that a one percent increase in the beef output price (P) leads to only a 0.016 percent increase in the average price paid by packers for fed cattle. The implication is that only a small portion of the fluctuations in beef output price is passed on to sellers through changes in fed-cattle prices. The effect of the number of head per lot (HEAD) on the price of fed cattle paid by packers is also positive and small. A one percent increase in the number of head per lot leads to an estimated 0.003 percent increase in the fed-cattle price.

The average price of fed cattle is sensitive to changes in the average weight per head in the purchase lot (WGT). On average, the fed-cattle price is discounted for over-finished or heavier exotic breeds by 0.122 percent for each one percent increase in the average weight per head. Thus, a steer or heifer that is 100 pounds (8.5 percent) over the mean average weight (1,171 lbs) costs packers $0.75/cwt (one percent) less than the mean average price paid.

Packers pay more for lots predominantly of steers than for any other cattle type, as expected. Packers pay $0.93/cwt less for predominantly heifer lots (TYPEH), $3.65/cwt less for predominantly mixed cattle lots (TYPEM), $5.45/cwt less for predominantly dairy cattle lots (TYPED), and $5.59/cwt less for predominantly fed Holstein lots (TYPEF).

Packers also pay a premium of $0.32/cwt for Yield Grade 1 cattle (YG1) and discount Yield Grade 3, 4, and 5 cattle (YG345) by $0.15/cwt on average relative to Yield Grade 2 cattle. On average, packers pay $0.11/cwt less for Select cattle (QGS) relative to Prime/Choice cattle. The highest average fed-cattle prices were paid in the January–to–March 1993 quarter (SEAS1) while the lowest were paid in the July–to–September 1992 quarter (SEAS3).

Relative Effects of Market and Quality Factors

To analyze the relative effects of continuous market and quality variables on the price paid by packers for fed cattle, a comparison of their respective elasticities reported in Table 2 is sufficient. An analysis of the relative fed-cattle price effects of discrete market and quality variables can be performed by comparing the estimates of the corresponding coefficients reported in Table 2.

The relative fed-cattle price effects of the continuous and discrete market and quality variables, however, cannot be compared directly. Such a comparison is facilitated by calculating the percentage change in each continuous explanatory variable required to offset the price effect of each discrete explanatory variable. From Equation 5, the change in fed-cattle price from a change in a given variable X_i is $\beta_i dX_i$. The changes required in any two variables X_1 and X_2 to achieve the same change in fed-cattle price is given by $\beta_1 dX_1 = \beta_2 dX_2$. If X_1 is a discrete

variable then $dX_1 = 1$, so that the percentage change in continuous variable X_2 (dX_2/X_2*100) required to equal the effect of a change in the discrete variable X_1 from 0 to 1 is calculated as $\beta_1/(\beta_2 X_2)*100$.

Following this procedure, Table 3 reports the percentage change in each continuous explanatory variable in the model that just offsets the effect of each discrete variable on the fed-cattle price calculated using the estimated coefficients and means of the respective continuous variables. The percentage changes in Table 3 within one standard deviation of each continuously valued explanatory variable (expressed as the standard deviation as a percentage of mean) are in bold type. Those that are within two standard deviations (two times the standard deviation as a percent of mean) are in italics. All other percentage changes are greater than two standard deviations of each continuously valued explanatory variable and probabilistically are outside the range of the data. That is, to be outside the range of the data, the probability that the reported percentage change in Table 3 is within two standard deviations of the corresponding continuous variable is less than 0.05.

Thus, for example, to have the same effect on the price of fed cattle paid by packers as procuring cattle through forward contracts (PROCFC) as opposed to the spot market, the output price (P) would have to drop by 145.4 percent (Table 3). One standard deviation of the output price expressed in percentage terms at the mean is only 13.5 percent (calculated from the data in Table 1). Dividing the standard deviation of a random variable by its mean gives the coefficient of variation, a percentage measure of variation. Using this measure allows meaningful comparisons of variability across variables. Hence the change necessary in the output price to have the same effect on the price of fed cattle paid by packers as procuring cattle through forward contracts is clearly outside the range of the data. The same is the case for output price and changes in procurement method from spot market to any other procurement method. That is, changes in output price within the normal range of the data have much smaller effects on the price of fed cattle paid by packers than do changes in fed-cattle prices resulting from using alternative procurement methods.

A comparison of the continuous variable elasticities in Table 2 suggests that the effect of a one percent change in the average weight per head (quality variable) is about six to 12 times larger (in absolute terms) than an equivalent change in any of the other three continuous market variables: (1) concentration measured by the RHHI, (2) plant slaughter capacity (CAP), and (3) output price (P). Thus cattle sellers face much larger potential discounts from every one percent increase in the weight of the cattle they market than from a one percent increase in packer concentration. That is, average weight per head, a quality variable that sellers can control, appears to be more important in determining the price sellers receive for their cattle than are regional concentration, plant capacity, or the price of beef, market variables over which sellers have no control.

At the same time, however, Table 3 shows that the type of cattle that sellers choose to market is likely a more important factor affecting the price of those cattle than their per head average slaughter weight. The percentage changes in the average weight required to have the same effect on the price of fed cattle as marketing dairy, fed Holsteins, heifers, or mixed cattle (59.7 percent, 59.7 percent, 10.2 percent, and 40.0 percent, respectively) instead of steers are much greater than one standard deviation expressed as a percentage of mean of the average slaughter weight per head (8.6 percent) and much greater than two standard deviations in most cases. In the same way, the type of cattle marketed by sellers is a more important factor in determining the price of fed cattle paid by packers than are any other market or quality variable (see Tables 2 and 3). Again, a quality variable controlled by sellers appears to be more important for the price paid by packers for fed cattle than are concentration, size economies, or other market and quality variables outside their control.

Packer concentration and economies of size also tend to be less important fed-cattle price determinants than the method packers choose to procure cattle but have equivalent effects to those of fed-cattle yield grade, distance of the sellers from the packing plant, and pricing method utilized by packers. That is, whether cattle are purchased on forward contract, as packer-fed cattle, or through some marketing arrangement rather than on the spot market is more important for the price of fed cattle paid by packers than whether the feeder faces relatively few large packers in the market. At the same time, however, pricing cattle on a carcass weight or formula basis rather than on a liveweight basis,

Table 3. Percentage Change in the Continuous Explanatory Variables Required to Offset Each Discrete Variable Effect.

	Continuous variables				
	Market variables			*Quality variables*	
Discrete variables	Output price (P)	Capacity (CAP)	Regional Herfindahl (RHHI)	Number head/lot (HEAD)	Average weight (WGT)
Market variables					
Procurement methods (Reference category: Spot market)					
Forward contract (PROCFC)	-145.36	-109.8	214.38	-690.48	19.05
Packer-fed (PROCPF)	-47.62	-35.97	70.23	-226.19	6.24
Marketing arrangement (PROC-MA)	45.11	34.08	-66.53	214.29	-5.91
Pricing methods (Reference category: Liveweight basis)					
Carcass weight (PRICC)	-15.04	-11.36	22.18	-71.43	1.97
Formula (PRICF)	-20.89	-15.78	30.80	-99.21	2.74
Quality variables					
Distance (Reference category: Over 300 miles)					
DIST1	15.87	11.99	-23.41	75.40	-2.08
DIST2	-5.85	-4.42	8.62	-27.78	0.77
Season (Reference category: Quarter 4)					
Quarter 1 (SEAS1)	311.61	235.39	-459.56	1,480.16	-40.84
Quarter 2 (SEAS2)	-1.17	-0.88	1.72	-5.56	0.15
Quarter 3 (SEAS3)	-153.72	-116.12	226.70	-730.16	20.14
Cattle type (Reference category: Steers)					
Dairy (TYPED)	-455.30	-343.94	671.47	-2,162.70	59.67
Fed Holsteins (TYPEF)	-467.00	-352.77	688.72	-2,218.25	59.67
Heifers (TYPEH)	-77.69	-58.69	114.58	-369.05	10.18
Mixed (TYPEM)	-304.93	-230.34	449.70	-1,448.41	39.96
Yield Grade (Reference category: Yield Grade 2)					
Yield Grade 1 (YG1)	26.73	20.19	-39.43	126.98	-3.50
Yield Grade 3, 4, or 5 (YG345)	-12.53	-9.47	18.48	-59.52	1.64
Quality Grade (Reference category: Prime/Choice)					
Select Grade (QGS)	-9.19	-6.42	13.55	-43.65	1.20

Numbers in bold, italic, and regular type represent percentage changes within one standard deviation, within two standard deviations, and greater than two standard deviations, respectively, of the continuous variables. DIST1 and DIST2 represent cattle purchased within 100 miles and between 100 and 300 miles of packer, respectively.

marketing Yield Grade 1 or Yield Grade 3 or higher cattle rather than Yield Grade 2 cattle, marketing Select rather than Choice grade cattle, or packer purchases of cattle from nearby (within 300 miles) rather than from more distant sellers are no more important to the price paid by packers for fed cattle and possibly less so than the level of regional packer concentration or the size capacity of the purchasing packing plant.

The season in which the fed cattle are purchased is also often more important than the level of concentration or the size of the purchasing plant. The level of concentration would have to drop by 460 percent and the slaughter capacity of the purchasing plant would have to increase by 235 percent in order for either variable to have the same positive effect on price that packer purchases of cattle in the first quarter of the year rather than in the fourth quarter of the year have on price, magnitudes of changes clearly outside the data's normal range. The same is the case with packer purchases of fed cattle in the first and third quarters rather than in the fourth quarter of the year.

Conclusions

We empirically investigate the effects of packer concentration and size efficiencies, selective use by packers of various fed-cattle procurement and pricing methods, and other market variables and quality characteristics on the prices paid by packers for slaughter cattle. For the analysis, we develop a hedonic price model that incorporates features of a farm-to-wholesale market margin analysis to quantify relationships between the slaughter-cattle price paid by packers for fed cattle and market and quality characteristics associated with specific slaughter-cattle lots purchased daily by the largest 43 beef packers over the period of one year (April 1992 through April 1993). The model explicitly allows firms to operate within possibly imperfectly competitive markets. This extension of the conventional hedonic framework makes our analysis unique and consequently contributes to the literature.

The empirical results indicate that while increases in regional concentration have a negative effect on the price of fed cattle, the effect is small both in absolute terms and relative to those of many market and quality characteristics of the cattle purchased. If an entire region is captured by a single firm, for example, our results suggest that the average price of fed cattle would fall by only three percent. This result is conditional on estimates using data for a single year, where much of the variation in fed-cattle prices and the RHHI is from cross-sectional differences among regions and plants. This result also is conditional on the pre-mandatory price period.

Despite the measured negative effect of concentration on the price of fed cattle, the results do not support a conclusion that packers are generally exerting spatial monopsony market power paying less for fed cattle from nearby sellers. In fact, the results indicate that, on average, packers pay a small premium for nearby cattle, the opposite of what would be expected under spatial monopsony conditions. This result is the net effect of offsetting market forces. While increasing concentration has a negative effect on the average price of fed cattle paid by packers, associated increases in slaughter capacity have a somewhat larger effect in the opposite direction. Perhaps in an effort to maintain production at maximum capacity, competition among packers for available fed cattle intensifies with increasing slaughter capacity. This effect tends to mitigate the negative price effects associated with greater regional concentration.

The results also suggest that each procurement and pricing method associated with captive supplies generates a discount in the price of fed cattle compared to that of cattle procured through the spot market and priced on a liveweight basis. The highest discount is associated with forward contracting followed by packer-fed cattle, and then formula pricing. Fed cattle priced on a carcass-weight basis receive discounts compared to fed-cattle priced on a liveweight basis. In contrast, cattle procured through marketing agreements receive premiums compared to cattle purchased in the spot market.

Nevertheless, we also find that quality variables controlled by sellers, such as average weight per head, cattle type, and timing of marketings, tend to be more important than packer concentration, size economies, procurement methods, or other market and quality variables outside the control of sellers in determining the fed-cattle price paid by packers. In fact, the type of cattle marketed by sellers is the most important factor determining fed-cattle price among the market and quality variables included in the analysis. Whether cattle are purchased on forward contract, as packer-fed cattle, or through

some marketing arrangement rather than on the spot market is more important for the price of fed cattle paid by packers than whether the feeder faces relatively few large packers in the market. Packer concentration and size economies, however, have effects on fed-cattle prices similar in absolute magnitude to pricing methods used by packers and yield and quality grade of the cattle purchased. Hence while captive supplies appear to influence prices paid by packers for fed cattle, there is no clear evidence that this behavior results from packer market-power exertion.

Our results clearly suggest that concentration is only one of a large number of market factors and quality characteristics of fed cattle that determine the price of fed cattle and is less important than many of them. In general, higher prices tend to be paid for fed-cattle lots with any of the following characteristics: (1) Yield Grade 1, (2) Prime/Choice grade, (3) primarily steers, (4) purchased from sellers within 100 miles of the packing plant, (5) purchased during the first quarter of the year, or (6) purchased by large capacity slaughter plants. Conversely, small lots of over-finished or heavier breed cattle or lots with any of the following characteristics are discounted: (1) Yield Grade 3, 4, and 5 cattle, (2) Select grade cattle, (3) predominantly heifers, dairy cattle, or mixed lots, (4) cattle purchased from sellers over 300 miles from the plant, (5) cattle purchased during the third quarter of the year, or (6) cattle purchased in the most concentrated regions.

Our results offer a set of hypotheses to be considered in the post-mandatory price-reporting period. While the analysis may be dated, nevertheless from a methodological point of view our analysis indeed makes a contribution in better understanding pricing behavior in the beef packing industry. This study is an analysis of the effects of concentration in beef packing on prices paid to producers during a period when the relative level of concentration is high. Since we found relatively little effect of concentration on prices during that period, it is unlikely that we would find such a relationship today. If we used data from today (that currently do not exist) and found little effect, the conclusion would be that either concentration has no effect or there is too little concentration to be able to measure an effect. The selected period offered a natural experiment.

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