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Rigidity in Packer-Feedlot Relationships

Lynn Hunnicutt, DeeVon Bailey, and Michelle Crook

Concentration in beef packing has risen dramatically in the past 25 years. We develop measures used to describe feedlot-packer relations: (1) a statistic based on the proportion of its sales a feedlot makes to a given packer, and (2) a measure of the switching behavior of feedlots. The measures are calculated using a confidential data set from the USDA Grain Inspection, Packers, and Stockyards Administration. Relationships are found to be both exclusive and stable. Causes for this rigidity are then examined using regression analysis. Transaction costs are shown to help explain why this market differs from a perfectly competitive one.

Key Words: beef packing, market relationships, transaction costs

JEL Classifications: Q13, L14, L66

Relationships between beef packers and cattle feedlot operations have become closer and more integrated over time, which are evidenced mostly by the level of contracting activity, often referred to as "captive" supplies, the industry has experienced during the last 10 years (USDA). The reasons why contracting relationships between packers and feedlot operators have become more important in the industry include transaction costs, price uncertainty, and the need packers have to operate processing plants efficiently (Ward et al. 1998). At the same time, cattle producers have

expressed fears about the impact of captive supplies on spot market prices (Azzam; Schroeder, Mintert, and Barkley). Although the issue of captive supplies and their effect on cattle prices has been a hotly debated and studied issue in recent years (in addition to the already cited work, see Hayenga and O'Brien, Ward et al. 1999, 1996), less attention has been given to precisely how individual relationships between packers and feedlots develop and endure in both the cash and contract markets.¹ Additional information about the underlying economic motivations for these relationships may provide important insights into why these relationships develop and why packers and feedlot operators allow themselves to become involved in preferential transaction arrangements in which the vast majority of a feedlot's cattle go to a single packing plant. Some believe that this can be

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This research was supported by cooperative agreement 99-ESS-01 with the USDA Grain Inspection, Packers, and Stockyards Administration. The opinions expressed herein are those of the authors and not necessarily those of the USDA or of the Grain Inspection, Packers, and Stockyards Administration. Additional support from the Utah Agricultural Experiment Station, Utah State University, Logan, UT 84322-4810, is acknowledged. Approved as journal paper 7629.

We thank David Aadland for helpful conversations regarding this project. The usual caveat applies.

¹ Ward et al. (1996) examined the determinants of the level of contracted cattle for individual *packing plants*. This study examines the determinants of the level of cash transactions for individual *feedlots*. Consequently, this study examines particular relationships between packers and feedlots, whereas the Ward et al. study did not.

explained by market power on the part of packers. An alternative explanation, and the one that is tested here, is that transaction costs might make it easier for both packers and feedlots to deal with a limited number of trading partners. Although market power per se is not the focus of this paper, it might be used to inform the policy discussion regarding the structure and operation of this market. If, for example, transaction costs relating to transportation of cattle from feedlot to packer are found to have a large effect on packer-feedlot relationships, programs designed to facilitate relationships between feedlot operators and packing plant buyers will have little effect on the market. A clearer understanding of relationships between packers and feedlots, as well as an understanding of which transaction costs best explain these relationships, may help inform policy makers and market participants about how these relationships develop.

Packers and feedlot operators who establish contracting arrangements have, by definition, rigid (predetermined and stable) relationships, at least in the short run. However, in the cash market both packers and feedlot operators should, at least theoretically, have choices among transaction partners, and the relationships between individual packers and feedlots may or may not be stable. If relationships in cash markets are rigid, then good economic reasons should be present to explain the rigidity. An understanding of these economic reasons might inform the policy debate regarding how these markets are structured and operate. Although direct tests for competitiveness are not performed in this paper, two new measures are used to provide a thorough description of relationships in a particular market for fed cattle, and an examination of the factors that might explain the relationships is performed.

Economic theory suggests that space plays an important role in determining partners to cattle transactions since cattle are a bulky commodity and transportation costs are significant. In this study a spatial statistic is created to explore the geographic and temporal relationships between packers and the feedlots from which they purchase by grouping feedlots by their primary customer (or, conversely,

examining packer "primary" market areas). The statistic is based on the proportion of its sales a particular feedlot makes to a given packer and classifies feedlots as having a preferential relationship with one or more packing plants. These relationships are easy to quantify if appropriate data are available. The statistic (and the focus of this entire paper) uses the feedlot as the unit of observation. That is, rather than look at the characteristics of feedlots from which a particular packer buys, this paper examines the characteristics of an individual feedlot's relationships with a group of packers.

There are several economic reasons why preferential cash market relationships exist between packers and feedlots. One is simply that one packer always offers a feedlot the highest raw price for its cattle, whereas another is that the packer offers the highest price net of transaction costs, suggesting that economies of size in completing transactions and the level of trust may determine choices of transaction partners. A third possible reason, although not directly tested for in this paper, is potential packer market power, since a packing plant may have more control over the terms of sale when it is a feedlot's major (or only) customer. If data on all bids received by a feedlot were available, market power could be inferred if feedlots consistently sold cattle to a particular packer even when higher prices (net of transaction costs) were offered by another packer. However, we did not have access to information on failed bids, and therefore make no claims regarding market power in the market for fed cattle. Instead, the goal of this paper is to provide different tools that might be used to describe relationships in the market for fed cattle and to demonstrate their use in a particular market in the United States.

The statistic we use allows us to examine stability of relationships in both the spot and contract markets. This allows us to examine the idea that feedlots may find it advantageous to trade fairly constant numbers of cattle with particular packers, regardless of whether the cattle are all under contract or not. Finding a preferential relationship between feedlots and packers would lend support to this theory.

This measure is then calculated using a confidential data set collected by the USDA Grain Inspection, Packers, and Stockyards Administration (GIPSA) from four beef packing plants in a single region. The data was made available through a cooperative research agreement and contains information on every purchase made by these packing plants over a 15-month period. To preserve confidentiality, only aggregate results are presented.

In the paper's second section, we examine the switching behavior of feedlots in our data set to gain a better understanding of the stability of relationships in this market. Feedlots that have a single primary customer may do so because that packer consistently offers the highest price net of transaction costs. But if any single plant does not always offer the highest price, some switching between customers should occur, at least in the spot market. We use a simple counting procedure to examine the number of periods feedlots with a single primary customer sold *only* to that packer. Relationships in both the spot and contract markets are quite stable. Over half of the feedlots examined sold only to their primary customer every time they entered the market. To further examine switching behavior, we looked at the market from the packer's point of view and calculated the percentage of throughput packers purchased from the feedlots that sold primarily to them. Close to half of packer throughput comes from these loyal feedlots. Packer-feedlot relationships thus appear quite stable.

Both packers and feedlot operators may benefit from these stable arrangements because they may reduce transaction costs for both buyer and seller, leaving all parties better off.² To examine this question, regression analysis is used to test whether transaction costs are related to the level of stability found in the market. If transaction costs explain the spot market stability found, then both parties

benefit from the market structure. Understanding which transaction costs have the largest influence on packer-feedlot relationships might help both policy makers and market participants gain a better sense of how and why relationships are formed in this market.

Describing Packer-Feedlot Relationships

Theory

The statistic used to characterize relationships in this market is based on one developed by Brorsen, Bailey, and Thomsen, who looked at the likelihood that a pen of cattle will be shipped from a given county to a particular marketing center.³ A county is defined as being in a trading center's primary market area if a larger percentage than expected of the lots sold from the county are shipped to the trading center. We modify this statistic to examine the likelihood that a given pen of cattle are sold from a particular feedlot to a particular packer. Suppose a region has K packing plants. If packers within the region are relatively close together, and assuming minimal price differentials, over time a feedlot should sell approximately the same number of pens to each packer. That is, the likelihood of a given pen of cattle going to a particular packer would be $1/K$. Feedlots that sell more than $1/K$ th of their total lots to a packer are said to have a preferential relationship with that packer. A feedlot may have up to $K - 1$ preferential relationships, so that there may be some degree of overlap between packing plant suppliers. Presumably, the more preferential relationships a given feedlot has, the less control any one of its customers has over its sales. Also, the larger the number of feedlots with several preferential relationships, the more competitive the market is likely to be.

Problems arise when examining small feedlots, as they are more likely to be found

² For example, feedlots may have a particular packer's pricing grid in mind as they purchase and finish their cattle. This reduction in cost of finding a buyer and negotiating price may explain the relationships seen in the data.

³ See Zhang and Sexton for an application of the literature on spatial market competition to beef packing. This paper does not directly consider spatial price discrimination. Instead, it describes the possibility of geographic division of feedlots among packers and the effects of this division on input prices.

to have preferential relationships even when they sell the same number of lots to each of their customers.⁴ For example, in a market with four packing plants, a feedlot that sold three pens would have three (or fewer) preferential relationships even if its sales were evenly divided. To obtain any information of use from these smaller feedlots, a smoothing technique developed by Brorsen, Bailey, and Thomsen was employed to infer how a smaller feedlot would behave if it sold an average number of pens.

In all of these formulas, p is the probability that a given lot is sold from feedlot $i \in \{1 \dots I\}$ to packer $k \in \{1 \dots K\}$. Define

$$\hat{p}_{ik}^0 = \frac{\sum_{n=1}^{N_i} y_{ikn}}{N_i}$$

as the probability that lot n is sold from feedlot i to packer k . N_i is the total number of sales made by feedlot i , and y_{ikn} is 1 if lot n was sold from feedlot i to packer k . To handle problems with smaller feedlots, appropriately weighted transactions from "nearby" feedlots were included in the test statistic. Thus, the "smoothed" estimate of the probability of shipment from feedlot i to packer k is a weighted average of $\hat{p}_{ik}^0$ and $\hat{p}_{ik}^*$, the (possibly smoothed) probability of sales to packer k from feedlots adjacent to i . This is given by

$$\hat{p}_{ik} = \frac{N_i \hat{p}_{ik}^0 + \gamma_i N_i^* \hat{p}_{ik}^*}{N_i + \gamma_i N_i^*}$$

where

$$\gamma_i = \begin{cases} 1 & \text{if } N_i + N_i^* \leq M \\ \frac{M - N_i}{N_i^*} & \text{if } N_i < M \text{ and } N_i + N_i^* > M \\ 0 & \text{if } N_i \geq M, \end{cases}$$

⁴ The data are from feedlots making at least one sale to one of the four packing plants in the region within the 15-month period. This does not allow a complete categorization of feedlot size, as only sales to these four packing plants are included. Feedlots may sell primarily in an outside market and only infrequently to these packers, which could cause a bias because some feedlots appear small when they are not.

where N_i^* is the total number of transactions the feedlots adjacent to i are involved in, and M is the number beyond which no smoothing is needed.

An important step necessary for carrying out the above calculations is determining which feedlots to include in the smoothing statistic. Let $\bar{d}$ be the average distance between feedlots and σ_d^2 be the variance of these distances.⁵ Feedlots closer than one standard deviation below $\bar{d}$ are defined as adjacent, since (assuming that distance between feedlots is normally distributed) there is only a 16% chance that feedlots will be closer to each other than this. It is assumed here that transportation costs do not affect the probability of feedlots within $\bar{d} - \sigma_d$ miles of each other selling to any one packer.

Under the null hypothesis of a competitive market, p_{ik} will equal $1/K$. Assuming that $p_{ik}^* = \theta p_{ik}$, there is no bias in the statistic if $\theta = 1$ (feedlot i and adjacent feedlots have the same transaction probabilities) or $\gamma = 0$ (there is no smoothing).

The central limit theorem applies if the number of observations is large enough. If we are testing whether $\hat{p}_{ik} = 1/K = 0.25$, then 140 observations are sufficient for the following statistic to have an asymptotic standard normal distribution:

$$Z_{ik} = \frac{\hat{p}_{ik} - p_0}{\sigma_{\hat{p}_{ik}}},$$

where

$$p_0 = p_{ik},$$

$$\sigma_{\hat{p}_{ik}}^2 = p_{ik}(1 - p_{ik})(N_i + \gamma_i^2 N_i^*) / (N_i + \gamma_i N_i^*)^2.$$

When the number of sales is not large enough to invoke the central limit theorem, we assume that $\theta = 1$ (i.e., that feedlot i and its neighbors are equally likely to ship to a given packer) and that lot sales are independent events. In this case, the binomial distribution is used to

⁵ Distances between feedlots were available because the data set included latitude and longitude coordinates for every feedlot.

determine the likelihood that $\hat{p}_{ik}$ is significantly different from $1/K$.

This test statistic allows for various values of p_{ik} in testing for preferential relationships. For example, the researcher might wish to define a feedlot's relationship with a packing plant as preferential only if it ships over three quarters of its output to that plant. In this case, $p_0 = 0.75$ would be used, and only those feedlots that sell statistically more than three quarters of their pens to a given packer would be said to have a preferential relationship with that packer. As reported below, most feedlots sell far more than $1/K$ th of their output to a single packer, which suggests that conclusions based on a more stringent definition of preferential would be similar.

Results

The feedlots were divided into quintiles based on number of lots sold. Feedlots in the lowest quintile sold only one or two lots over the entire 15-month period. As noted, calculating the test statistic for small feedlots may not be appropriate, since the proportion of sales going to any one packer takes on a limited number of values. Since these feedlots tend to bias the results toward finding a significant number of preferential relationships, the calculations were performed with the lowest quintile deleted from the sample. Even with the smoothing technique, including the smallest feedlots leads to finding many more preferential relationships.

The mean distance between feedlots was 191.4 miles, and the standard deviation about the mean was 128.5 miles.⁶ Subtracting one standard deviation from the mean gives 62.9 miles, and feedlots within this distance from each other were assumed adjacent.⁷ Since the data set contains information on sales to four packing plants, the test is whether the proba-

bility of sale from a given feedlot to a given packer is significantly greater than 25%, and the central limit theorem is invoked for feedlots that (when combined with their neighbors) sold more than 140 lots. For smaller feedlots, the binomial distribution is used to determine the likelihood that $\hat{p}_{ik}$ is significantly different from 25%.

The smoothing procedure used in the study assumes that nearby feedlots behave similarly, which contradicts results not shown here that suggest that neighboring feedlots often have preferential relationships with different packers. This makes it unclear which "nearby" feedlots to include in the weighting scheme. To avoid these problems, the statistic was also calculated without the smoothing procedure. When small feedlots' behavior is not adjusted for size, over 25% more feedlots have a single preferential relationship (see Table 1). Feedlots making three or fewer sales easily account for this increase.

Lot size may also affect the calculations. For example, if a feedlot sells many very small lots to a particular packer, one can conclude it has a preferential relationship with that packer, even when most of the cattle it handled went to a second packer. To examine this issue, the statistic is also calculated using the number of head sold, rather than number of lots.

Table 1 presents the results for this part of the analysis. They appear quite robust, since in all calculations the majority of feedlots had a preferential relationship with a single packing plant. For example, when small feedlots are excluded and the smoothing technique is used, 149 (57%) of the 260 feedlots that sold in the spot market had a preferential relationship with a single packer. Continuing to exclude small feedlots and basing the calculation on number of head, 189 (72.69%) of the 260 feedlots that sold in the spot market had a single preferential relationship. Relationships in the spot, contract, and overall markets are found to be preferential, no matter what the basis of calculation.

Feedlot Switching Behavior

According to Gort, if large firms compete vigorously for market share, instability in market

⁶ Twelve feedlots were more than two standard deviations (257 miles) from all others, and thus "adjacent" to no one. These were removed from the sample, along with two feedlots missing coordinate data.

⁷ Using two alternative definitions of "adjacent"—feedlots within 50 and 100 miles of the one under examination—did not significantly affect our results.

Table 1. Categorization of Exclusive Relationships Between Feedlots and Packers

Number of Exclusive Relationships	All Feedlots (No. in the Market)			Excluding Small Feedlots (No. in the Market)		
	Spot (311)	Contract (150)	Entire Market (335)	Spot (260)	Contract (145)	Entire Market (279)
Smoothed						
None	51 (16.4)	27 (18)	42 (12.3)	34 (13.1)	24 (16.6)	33 (11.8)
One	183 (58.8)	83 (53.3)	209 (62.4)	149 (57.3)	81 (55.9)	162 (58.1)
Two	66 (21.2)	31 (20.7)	76 (22.7)	66 (25.4)	31 (21.4)	76 (27.2)
Three	11 (3.5)	9 (6)	8 (2.4)	11 (4.2)	9 (6.2)	8 (2.9)
Unsmoothed						
None	4 (1.3)	2 (1.3)	4 (1.2)	1 (0.4)	2 (1.4)	1 (0.4)
One	266 (85.6)	137 (91.3)	295 (88.1)	218 (83.9)	132 (91)	242 (86.7)
Two	41 (13.2)	11 (7.3)	36 (10.8)	41 (15.8)	11 (7.6)	36 (12.9)
Three	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
No. Head						
None	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
One	239 (76.9)	135 (91.0)	263 (78.5)	189 (72.7)	130 (89.7)	208 (74.6)
Two	69 (22.2)	15 (10)	68 (20.3)	68 (26.2)	15 (10.3)	67 (24.0)
Three	3 (1.0)	0 (0)	4 (1.2)	3 (1.2)	0 (0)	4 (1.4)

Note: Each column contains the number of feedlots with none, one, two, or three exclusive relationships, with percentages of the total number of feedlots being considered in parentheses.

shares ensures competitive behavior even when concentration is high. For example, a feedlot that sells most of its output to a single packer may regularly sell a small portion to other packers, or may have switched between primary customers one or more times during the period under observation. This idea was expanded upon by Davies and Geroski, and Baldwin and Gorecki, who analyzed manufacturing industries in the United Kingdom and Canada and found that concentration and stability are not always positively correlated. Thus, an industry may be concentrated, but relationships between buyers and sellers so

unstable that prices remain competitive. The statistic developed above may mask instability, so additional analysis is needed to identify instability in the proportions that feedlots sell to a single packer.

To examine stability of this market, the sample was divided into 2-week periods, and the percentage of periods feedlots with a single preferential relationship sold only to their primary customer was calculated. This is a more stringent test, since it now requires 100% of sales to go to a primary customer, rather than statistically more than 25%.

For the overall market, the feedlots, on av-

Table 2. Percentage of Periods Feedlots Sell Only to Primary Customer

	Overall Market (%)	Spot Market (%)	Contract Market (%)
Average	80	94	80
Median	100	100	100
Standard deviation	30	23	31

erage, sell 80% of the time exclusively to their primary customer. That is, in 80% of the 2-week periods in which they make sales, feedlots sell all of their cattle to their primary customer, rather than to other packers. An average feedlot, then, which sold 10 times during the 15-month period for which we have data, would have sold its entire show list to its primary customer eight of those 10 times. In the contract and spot markets, feedlots sell exclusively to their primary customer 94% and 80% of the time, respectively. Most feedlots sell as much or more than the numbers shown above, as the median and mode in all cases are both larger than the mean. In fact, over half of all feedlots with a single preferential relationship sold all of their output to their primary customer. That is, there is over a 50% chance that a feedlot that sold 10 times during our sample period sold its entire show list to its primary customer *all 10* of those times. These results give further evidence that feedlots tend to deal only with a single packer through contracts *and* in the spot market.

This market appears to have both preferential and stable relationships. However, Table 2 does not tell if packers depend on a select group of feedlots for a large percentage of their throughput. One packer may buy all of its throughput from those with which it has a preferential relationship, whereas another purchases only a limited amount from such feedlots. To get a sense of the interdependence of feedlots and packers, the percentage of each packer's throughput purchased from feedlots that sold it the majority of their output is calculated. On average, packers purchased just less than half (47%) of their throughput from feedlots at which they were the primary customer. Not surprisingly, most of this exclusiv-

ity can be explained by contracted cattle. Just over three quarters (76%) of the contracted throughput came from "preferred" feedlots, whereas only one quarter (26%) of spot market throughput is purchased from preferred feedlots. Not surprisingly, packer relationships with preferred feedlots appear to be much more stable in the contract market than in the spot market.

Factors Influencing Spot Market Stability and Exclusivity

Feedlot operators should adjust sales based on the relative prices offered by packers and transaction costs. Since neither transaction costs nor relative prices offered for individual lots of cattle are directly observable, we proxy for them and include a variable based on price differences in the following estimating equation:

$$(1) \quad PROP_{ijt} = \phi_0 + \phi_1 PROP_{ijt-1} + \phi_2 NEG_{ijt} \\ + \phi_3 FLSIZE_{it} + \phi_4 TOTLOT_t \\ + \omega_1 MPD_{jst} + \phi_5 PERSIST_{it} \\ + \phi_6 CS_{ijt} + \sum_{j=1}^3 \psi_j D_j + \xi_{ijt},$$

where $PROP_{ijt}$ is the proportion of lots sold in the spot market by the i th feedlot to the j th packer during the t th 2-week period (only spot market sales are considered since we assume that short-term adjustments cannot be made in the proportion of cattle sold under contract). $PROP_{ijt-1}$ controls for the effect of previous dealings on packer-feedlot relationships and measures the (transaction) cost of finding different exchange partners. If it is important, its coefficient will be positive and significant.

The binary variable NEG_{ijt} is equal to 1 if there was a negative change from the last time period in the proportion of cattle sold by the i th feedlot to the j th packer and was used to examine whether or not negative and positive changes in proportions tend to be equal (symmetric). This is similar to irreversibility as discussed in Ferris. It measures rigidity in the market and is related to the transaction cost of

finding a new trading partner. We hypothesize that this cost makes relationships more stable than they otherwise would be. If the adjustment in proportions is asymmetric downward, then NEG_{ijt} will have a negative, significant coefficient.

$FLSIZE_{it}$ is the total number of lots sold by the i th feedlot in both the spot and contract markets during period t . Feedlot size is related to (transaction) costs of negotiating a sale, as economies of size in developing and maintaining relationships may reduce per pen transaction costs. If this is true, then $FLSIZE_{it}$ will have a positive, significant coefficient.

MPD_{jxt} is the largest current period difference between actual spot market price paid on a live weight basis for choice, yield grade 3 steers by packer j and that paid by one of the other three packers, x . Notice that although a particular packer may offer the largest price during one 2-week period, another packer may be in this position in the next 2-week period. Thus, we do not attempt to distinguish competition between any two specific packers with this variable. Rather, we are interested in how sellers react to price differences. The price of choice, yield grade 3 steers is used as this type of animal is basically an industry standard for pricing and serves as the base price used in many grid pricing mechanisms. It would be preferable to use the actual price differences between packing plants, but this proved difficult because not all plants bought similar lots in any given period. Comparing the price paid for a pen of dairy steers to that paid for a pen of choice Angus steers would be misleading, and since we have data available for successful bids only, it is hard to estimate what would have been paid by any given packer for a particular pen of cattle. To avoid this problem, we used a more standardized lot, which was purchased by all packing plants during the months under examination. Lots were included in our price calculations if they contained 50% or more choice, yield grade 3 steers. As noted, more specific prices for each lot sold would be preferred, but the only prices available are those for successful bids. Thus, we proxy for offered price differences by using prices paid for this industry standard lot. All

packers purchased at least one lot consisting of 50% or more choice, yield grade 3 steers in every 2-week period, so that price differences reported here are based on actual prices offered by each packer. One would expect the coefficient on this variable to be positive and significant since relatively high base prices offered by alternative packers (negative MPD_{jxt}) should place pressure to reduce the proportion of spot market cattle sold to a particular packer.

One possibility is that relationships are stable because price differences are small and fleeting so feedlot operators will tend to accept their regular buyer's bid to avoid switching costs over price differences that are neither large nor persistent. To test for this possibility, the variable $PERSIST_{it}$, a binary variable, was set to 1 if any competing packer base price for choice, yield grade 3 steers was more than \$0.10/cwt. Higher than the actual sale price for two or more consecutive (2-week) periods is included in Equation (1). If persistent price differences affect the proportion of sales going to a given packer, the coefficient on $PERSIST_{it}$ will be negative and significant. The reason for this is that MPD is negative if choice steer prices offered by an alternative packer are higher than those of the purchasing packer. One would expect that the more negative is MPD , the smaller the proportion sold to the purchasing packer. Unfortunately, there is some correlation between $PERSIST_{it}$ and MPD_{jxt} . When offered prices for choice, yield grade 3 steers changed little over an extended period, the data contained observations in which a particular packer offers more than \$0.10/cwt more than another for more than two periods and when the difference in price offered is also the maximum. In this case, neither MPD_{jxt} nor $PERSIST_{it}$ changed, and the two variables were thus collinear. Because of this collinearity, $PERSIST_{it}$ had to be dropped from the final estimating equation.⁸

⁸ In a preliminary ordinary least squares (OLS) regression not reported here, the coefficient on $PERSIST$ was positive and significant. This is probably the result of the inability of the standard grade (choice, yield grade 3 steers) to capture all the interactions between packers affecting purchasing levels for individual feedlots.

Table 3. Summary Statistics for Regressors Other than Price

Variable	Mean	Std. Dev.	Minimum	Maximum
Irreversibility (NEG_{ijt})	0.11	0.31	0	1
Lagged spot market sales ($PROP_{ijt-1}$)	0.25	0.38	0	1
Size of feedlot ($FSIZE_{ijt}$)	6.21	6.95	1	69
Size of market ($TOTLOT_{ijt}$)	743.00	86.02	551	918
Maximum price difference (MPD_{ijt}) ^a	-0.27	0.42	-1.77	0.78
Persistent price differences ($PERSIST_{ijt}$)	0.02	0.13	0	1
Percent contract sales (CS_{ijt})	0.06	0.22	0	1

Notes: Number of observations for all variables = 14,908. Std. Dev. is standard deviation.

^a Negative numbers imply larger prices offered by competing packers. MPD calculated using sales to all four packing firms.

Based on the notion that the threat of retaliation for switching buyers is less costly for feedlots during periods of high supply, we included the number of cattle offered for sale in the market each period, $TOTLOT_t$. If feedlot operators fear retaliation from their primary customers for reducing their sales, they are more likely to do so during periods of large supplies, when the cost to packers is diminished. Additionally, since it is less costly to punish feedlots during periods of large supply, packers may reduce the amount they purchase from disloyal feedlots when cattle are abundant. Thus, the coefficient on $TOTLOT_t$ should be negative and significant.

Finally, we expect that costs for completing spot market transactions are reduced if the feedlot operator sells to the packer under contract. This is related to transaction costs of finding a trading partner and bargaining over the terms of trade. Contract sales imply that the feedlot and the packer have some degree of trust in their business relationship. CS_{ijt} , the proportion of all contract sales of the i th feedlot during time period t sold to packer j should thus have a significantly positive coefficient. To account for packer-specific characteristics not included elsewhere, we include three dummy variables D_j , with the fourth packer serving as the base. Equation (1) includes a lagged dependent variable, but the Durbin h -test indicated no presence of autocorrelation.⁹ Sum-

mary statistics for the regressors and for the variable $PERSIST_{ijt}$ are given in Table 3.

One variable that was left out of the regression was distance from the feedlot to the packing plant. This is likely to be a good measure of the transaction costs involved in this market. However, it cannot be included in this regression because it is unchanging for each feedlot-packer pair. Recall that the dependent variable is the proportion of spot market cattle from feedlot i to packer j for each 2-week period. Since the distance between feedlot i and packer j does not change, it falls out of a panel data estimation, which was the technique used. The effect of distance (and any other fixed variable) is captured by the fixed-effects intercept terms, which were included in the estimation of Equation (1).

The results for the Hausman test for random effects and the F -test for fixed effects indicate that a fixed effects model is appropriate. This procedure as used to estimate Equation (1) and parameter estimates are reported in Table 4. Because the panel data estimator estimates coefficients based on separate intercept dummies for each feedlot selling to each of the different packers, the dummies for different packers ($\sum_{j=1}^3 \Psi_j D_j$) fall out of Equation (1) and are not reported in Table 4.

Our results support the notion that relationships between feedlots and packers are stable. The coefficient for lagged differences in spot market sales ($PROP_{ijt-1}$) is positive, less than 1 in absolute value, and is significantly different than zero. Downward adjustments in proportions tend to occur for sales involving a

⁹ The autocorrelation coefficient estimated by LIM-DEP's panel data estimator was -0.019945. This yielded a Durbin h -statistic of about -0.11, which accepted the null hypothesis of no autocorrelation (Greene, p. 542).

Table 4. Regression Results, Dependent Variable = % Spot Market Sales to Packer

Variable	Coefficient
Lagged spot market sales ($PROP_{ijt-1}$)	0.3436** (0.0081)
Irreversibility (NEG_{ijt})	-0.4986** (0.0072)
Size of feedlot ($FLSIZE_{it}$)	0.00078 (0.00044)
Size of market ($TOTLOT_i$)	$609 \times E^{-6}$ ($2.03 \times E^{-5}$)
Percent contract sales (CS_{ijt})	-0.0265** (0.01)
Maximum price difference (MPD_{jxt})	0.0031 (0.0047)
ρ	-0.019945
Adjusted R^2	0.7084

Notes: Hausman statistic for random effects is 3306.16***, F -test statistic for fixed effects is 44.27***, standard errors are given in parentheses; *Significant at 5%; **Significant at 1%.

smaller proportion of feedlot output (NEG_{ijt}). This suggests that the less a feedlot sells to a packer, the more likely it is to reduce the proportion sold to that packer. However, downward adjustments were experienced in only approximately 5% of the observations. This suggests that feedlots frequently make incremental upward adjustments in proportions sold and that larger downward adjustments were made all at once, rather than incrementally. The coefficient for feedlot size ($FLSIZE_{it}$) was positive and marginally significant ($p = .0717$), suggesting that economies of size play a role in the establishment of relationships between feedlots and packers since larger feedlots tend to sell a greater proportion of the cattle to one packer than do smaller feedlots. The size of the total market ($TOTLOT_i$) does not affect the proportions of cattle sold by individual feedlots to separate packers. This indicates that no evidence exists in these data to suggest that feedlots adjust proportions sold to their principal customer only when cattle supplies are plentiful in order to avoid possible retaliation from their principal customer. Surprisingly, a larger proportion of contract sales from feedlot i to packer j (CS_{ijt}) reduces the portion of spot market transactions be-

tween them. This might be because packers rely on different feedlots for spot market transactions than for contracted cattle. Alternatively, it could be that feedlots that contract their cattle simply sell very little on the spot market. A third alternative is that feedlots tend to sell about the same proportion of their cattle to the same packers week after week, regardless of whether they are sold in the cash or contract market. Consequently, increases in the proportion of cattle contracted will reduce spot sales to a particular packer in a particular week. Conversely, during those weeks when a smaller proportion of cattle are sold under contract to a particular packer, the number of spot market cattle sold to the packer will increase. This again suggests the tendency to establish and maintain a stable relationship between packers and feedlots regardless of whether cattle are purchased under contract or on the spot market.

The coefficient on the maximum price difference (MPD_{jxt}) is not significantly different from zero. This suggests that price differences for the base grade (choice, yield grade 3 steers) do not play a critical role in determining which packer purchases a feedlot's cattle. Of course this may be because the price differences used in the regressions are calculated for a standard lot, rather than based on each individual lot.

Previous spot market sales and the presence (or absence) of a contracting relationship appear to have the largest influence on the proportion of spot market sales made to a particular packer. The results imply that transaction costs are a major reason why feedlots and packers establish and maintain stable relationships, whereas price differences have limited influence on relationships in this market. These results do not suggest that price differences do not matter, but they do imply that transaction costs are important and can help explain the stability and rigidity that appears in the market for fed beef. Our results suggest that transaction costs need to be considered in the analysis of relationships between feedlots and packers and in the design of any proposed regulation, since reducing transaction costs may benefit both the feedlot and the packer.

Conclusion and Extensions

This paper has developed two easily calculated measures of the strength of relationships between buyers and sellers in any industry. These measures provide new ways to describe the structure of markets, which can be helpful in understanding the issues buyers or sellers may face. The measures are applied to the market for fed beef in a major beef production location in the United States. Inasmuch as the measures do not rely on hard-to-measure variables, they allow for more definitive conclusions regarding relationships between packers and feedlots in this market. Regression analysis is then used to examine the determinants of the spot market relationships, which gives some evidence as to why packers and feedlot operators become involved in preferential and stable transaction arrangements.

The first measure classifies packer-feedlot relationships as preferential when a feedlot sells an unusually large proportion of its output to a single packer. In a market observed over time, assuming similar offer prices, feedlots should sell approximately the same proportions to all packers in the area. Feedlots that sell more to a particular packer are said to have a preferential relationship with that packer. Over half of the feedlots in the sample have a single preferential relationship. The second measure is more stringent, as it uses the criterion of *all* sales going to the primary customer. This measure is given by the percentage of 2-week periods a feedlot with a single preferential relationship sold *only* to its primary customer. Over half of all feedlots with a single preferential relationship *always* sell to their primary customer exclusively. This suggests that relationships in both the spot and contract markets are preferential and stable. This dependence appears to be mutual, as packers purchase just under half of their throughput from these feedlots.

The stability found in both the spot and contract markets suggests that attempts to regulate the contract market only to resolve "problems" related to captive supplies may have minimal impact on the distribution of cattle sales among packers. Given that rigidity

exists in both the spot and contract markets, regulations regarding the amount of contracted cattle allowable between a feedlot and packer may be overcome by increasing the number of animals traded in the spot market. As we note below, the regression analysis suggests that transaction costs may explain some of this stability. If this is the case, then the need for regulations to make the market more competitive may not be as great as previously thought.

In the paper's third section, we look at determinants of the rigid relationships found by developing a regression model that includes measures of transaction costs as regressors. Some of these measures are found to be significantly related to the percentage of spot market sales going to each packer. Previous proportions, the presence of a contracting relationship, and the one-sided nature of changes in proportions (increases in proportions sold to a given packer occur much more frequently than decreases in proportions sold, although the less-frequent decreases in proportion tend to be larger in size) have the largest influence on spot market proportions. Price differences do not appear to have a significant effect on how many cattle a feedlot sells to each packer. However, our analysis relied on prices for a standard lot, rather than the actual lots sold. Additional data on failed bids might be helpful in resolving the relationship between price differences and proportions sold. It appears that transaction costs are significantly related to the stability of this market.

These results suggest that relationships in the market for fed beef are quite stable, but that stability can be understood as part of an attempt on both packers' and feedlots' part to reduce transaction costs. The findings strongly indicate it is necessary to account for transaction costs in any analysis attempting to determine whether or not the market for fed beef is competitive. Although this paper does not take a position on whether or not the market is competitive, it does imply that attempts to increase competitiveness in this market may not be effective unless they account for the apparent attempts of both packers and feedlots

to reduce the transaction costs involved in buying and selling fed cattle.

[Received November 2003; Accepted June 2004.]

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