Measuring Market Power with Variables Other than Price

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1 Introduction

Concentration in the beef packing industry has been rising for the past 25 years. This has generated both concern among policymakers and interest from academic economists about the ability of packing plants to exploit their market position by influencing the conditions under which they purchase live cattle. Several studies of oligopsony power in beef packing have led to mixed results (see Azzam (1998) for an overview of this literature). Some studies find a small but significant degree of market power (Bhuyan and Lopez (1997), Koontz, Garcia and Hudson (1993), Schroeter (1987), Schroeter and Azzam (1990)), while others find no evidence that packers are able to exploit their position in the purchase of fed cattle (Azzam and Park (1993), Morrison (1997), Muth and Wohlgenant (1998)).

In most studies, exercise of market power is defined as the ability of packing firms to reduce the price they pay for their inputs below a competitive level.[1] Unfortunately, without further assumptions, one cannot know what prices would be if the industry were "competitive." Most studies solve this problem by noting that packer costs determine what a competitive level of prices would be. They then use an estimate of costs based on input prices paid, processing costs, and marginal value product. However, as is well known, costs and marginal value product are quite difficult to measure accurately, let alone obtain from packing firms. Alternatively, some studies examine the path of prices over time, looking for collusive behavior among packing firms (see, for example, Koontz et al. (1993), Weliwita and Azzam (1996), Azzam and Park (1993)). However, these studies are not able to characterize the degree of market power which packers may possess, since they do not involve estimating what competitive prices would be. Instead, they give evidence as

[1] See Schroeter (1987) for a theoretical development of the standard measure of market power.

to whether packers do (or do not) use a particular collusive strategy to maintain the price of fed beef below what it would be in a competitive level.

Given the measurement problems and the mixed results obtained thus far, we suggest that alternatives to traditional market power measures should be examined. To that end, we create a statistic designed to explore the geographic and temporal relationships between packers and the feedlots from which they purchase. We are able to avoid the problem of knowing what competitive prices would be by using an indirect measure of packer behavior that is related to the exercise of market power but does not need cost and marginal value product data. Instead, our statistic is based on the proportion of its sales a particular feedlot makes to a given packer. This is easy to quantify if appropriate data are available.

Our statistic allows us to classify feedlots as having an exclusive relationship with one or more packing plants. This gives an indirect measure of 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. Our underlying hypothesis is that packers may control their cattle supplies by developing exclusive relationships with particular feedlots. If there is limited overlap among these relationships, then packers may have the ability to control terms of sale as well. In effect, exclusive relationships may explain why the market for fed beef differs from a perfectly competitive market.

The idea of feedlot loyalty is related to notions of captive supplies. One theory of the relationship between packing firms and their suppliers suggests packers capture needed supplies through contractual arrangements with feedlots (Schroeder, Mintert and Barkley (1993), Hayenga and O'Brien (1992), Ward, Koontz, Dowty, Trapp and Peel (1999), Ward, Koontz and Schroeder (1998), Ward, Schroeder, Barkley and Koontz (1996)). Our statistic goes further, and looks at the possibility that packers may be able to "capture" an entire feedlot, instead of just a portion of the feedlot's output. Finding an exclusive relationship between feedlots and packers would lend support to this theory. It is important to note, however, that packer market power is only one of many possible reasons for such exclusive relationships. To address this question, we perform the regression analysis described below.

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 to us 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.

Our results suggest that relationships between feedlots and packers are extremely exclusive. The majority of feedlots in our sample sell more than expected to only one of four neighboring packing plants. Furthermore, these feedlots on average sell *only* to their primary customers most periods in which they sell.

In the paper's second section, we examine the switching behavior of feedlots in our data set. Feedlots may have a single primary customer because this packer consistently offers the highest price. It is unlikely that any single plant will always offer the highest price, so that in a perfectly competitive market, absent transaction costs or other differences among feedlots, feedlot sales should regularly switch between plants. Thus, the more often feedlots switch customers, the more likely it is that the market is competitive, even when most feedlots have a single primary customer. 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 this market are surprisingly 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 calculate 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.

While these results imply that packers *may* be exercising market power, the relationships found may also benefit feedlots. They may reduce transaction costs for both buyer and seller, leaving all parties better off.[2] To examine this question, we use regression analysis on the effect of lot quality characteristics and transaction costs on the relationships described above. If transaction costs and lot characteristics explain exclusivity, then both parties benefit from the market structure. While this would not rule out packer exercise of market power, it makes it difficult to characterize the effects as detrimental to feedlots.

2 Describing Exclusive Relationships

2.1 theory

Our statistic is based on one developed by Brorsen, Bailey and Thomsen (1997), who look 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, we would expect that over time a feedlot would 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 $1/K$.[4] Feedlots which sell more than $1/K^{th}$ of their total

[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 exclusive and stable relationships seen in the data.

[3] See Zhang and Sexton (2000) for an application of the literature on spatial market competition to beef packing. Our work does not directly consider this spatial price discrimination. Instead, we study the possibility of geographic division of feedlots among packers and the effects of this division on input prices.

[4] The choice of $1/K$ follows the work of Brorsen et al. (1997). It assumes that all plants are equally likely to purchase a given pen of cattle. It has been suggested that if one of the plants is much larger than others

lots to a packer are said to have an exclusive relationship with that packer.[5] A feedlot may have up to $K-1$ exclusive (preferential) relationships, so that we can characterize the degree of overlap between packing plant suppliers. Presumably, the more exclusive 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 more than one exclusive relationship, the more competitive the market is likely to be.[6]

Problems arise when examining small feedlots, as they are more likely to have an exclusive relationship even when they sell the same number of lots to each of their customers.[7] For example, in a market with four packing plants, a feedlot that sold three pens would have three (or fewer) exclusive relationships even if its sales were evenly divided. To obtain any information of use from these smaller feedlots, we use a smoothing technique developed by Brorsen et al. (1997) 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 $i \in \{1..I\}$

in the area, feedlots would sell more than $1/Kth$ of their output to this plant. We have done preliminary calculations in which the definition of exclusive relationship depends on plant size, but these do not appear to affect our results. Further, as we will see in table 2 below, it appears that feedlots with a single exclusive relationship sell almost all of their output (much more than $1/Kth$) to their primary buyer, which implies that the results presented are robust to the definition of exclusivity we have selected.

[5] Since the statistic developed requires only that packers sell more than 25% of their output to a single packer, one might describe relationships in this market as preferential, rather than exclusive. However, as we will see below, most feedlots sell far more than 25% of their output to a single packer. Thus, we continue to describe packer-feedlot relationships as "exclusive".

[6] It has been suggested that some exclusive relationships between feedlots and particular packers may force other exclusive relationships between other feedlots and packers. For example, if three-fourths of all the feedlots in an area all have exclusive relationships with three out of four packers in that area, then the only way the fourth packer could ensure adequate supply to meet its capacity would be to establish its own exclusive relationships with the remaining fourth of the feedlots in that area. The data available to us do not allow us to test for this sort of causality, although it should be noted.

[7] Our data are from feedlots making at least one sale to one of these four packing plants within the fifteen-month period. Unfortunately, we cannot completely categorize 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 since of some feedlots appear small when they are not.

to packer $k \in \{1..K\}$. We define:

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

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 one if lot n was sold from feedlot i to packer k. To handle problems with smaller feedlots, we include transactions from "nearby" feedlots. Thus, our smoothed estimate of the probability of shipment from feedlot i to packer k is a weighted average of $\hat{p}^0_{ik}$ and $\hat{p}^*_{ik}$, the (possibly smoothed) probability of sales to packer k from feedlots adjacent to i. This is given by:

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

where

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

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 $\overline{d}$ be the average distance between feedlots, and σ^2_d be the variance of these distances.[8] Feedlots closer than one standard deviation below $\overline{d}$ 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

[8] We were able to calculate the distances *between feedlots* because the data set included latitude and longitude coordinates for every feedlot.

than this. We argue 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 our 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 $p_0 = p_{ik}$, $\sigma^2_{\hat{p}_{ik}} = p_{ik}(1 - p_{ik})(N_i + \gamma_j^2 N_j)/(N_i + \gamma_i N_i^*)^2$. 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 and use the binomial distribution to 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 exclusivity. For example, the researcher might wish to define a feedlot's relationship with a packing plant as exclusive 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 which sell statistically more than three-quarters of their pens to a given packer would be said to have an exclusive relationship with that packer.

2.2 results

We divided the feedlots into quintiles based upon number of lots sold. Feedlots in the lowest quintile sold only one or two lots over the entire 15-month period. As noted, calculating our 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 our results toward exclusivity, we perform our calculations with the lowest quintile deleted from the sample. When the smallest feedlots are included, we find much more exclusivity, even with the smoothing technique.

The mean distance between feedlots was 191.4 miles, and the standard deviation about the mean was 128.5 miles.[9] Subtracting one standard deviation from the mean gives 62.9 miles, and feedlots within this distance from each other were assumed adjacent.[10] Since we are testing whether the probability of sale from a feedlot to a given packer is significantly greater than 25%, we invoke the central limit theorem for feedlots which (when combined with their neighbors) sold more than 140 lots. For smaller feedlots, we use the binomial distribution to determine the likelihood that $\hat{p}_{ik}$ is significantly different from 25%.

The smoothing procedure used assumes that nearby feedlots behave similarly, which contradicts the results (given below) suggesting that neighboring feedlots often have exclusive relationships with different packers. It is also not clear which "nearby" feedlots to include in the weighting scheme. To avoid these problems, we also calculate our statistic without the smoothing procedure. When small feedlots' behavior is not adjusted for size, over 25% more feedlots have a single exclusive relationship (see Table 1). Feedlots making three or fewer sales easily account for this increase.

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

Table 1 presents our results. They appear quite robust, since in all calculations the

[9] Twelve feedlots were more than 2 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.

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

majority of feedlots had an exclusive relationship with a single packing plant. Additionally, we examined transactions in the spot and contract markets taken separately, and find that relationships are exclusive in both subsectors of the market.

Insert Table 1 here

3 feedlot switching behavior

According to Gort (1963), if large firms compete vigorously for market share, instability in market 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 (1997), and Baldwin and Gorecki (1994), who analyzed manufacturing industries in the U.K. 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 which limits packers' ability to control their terms of purchase.

To examine stability of this market, we divided our sample into two-week periods, and calculated the percentage of periods feedlots with a single exclusive relationship sold only to their primary customer. This is a more stringent test, as we now require 100% of sales to go to a primary customer, rather than statistically more than 25%.

Insert Table 2 here

For the overall market, the feedlots, on average, sell 80% of the time exclusively to their primary customer. 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 exclusive relationship sold all of their output to their primary customer. These results give further evidence that feedlots tend to deal with a single packer exclusively, through contracts *and* in the spot market.

This market appears to have both exclusive and stable relationships. However, table 2 does not tell us if packers depend on their loyal feedlots for a large percentage of their throughput. One packer may buy all of its throughput from such loyal feedlots, while another purchases only a limited amount from the feedlots that sell to it exclusively. In the first case, the relationship between packer and feedlot is likely to be one of mutual interdependence, while in the second the packer may be better positioned to make purchases from secondary feedlots if its terms of sale are refused by its usual sellers. To get a sense of the interdependence of feedlots and packers, we calculated the percentage of its throughput each packer purchased from feedlots that sold it the majority of their output. On average, packers purchased just less than half (47%) of their throughput from feedlots at which they were the only primary customer. Not surprisingly, most of this exclusivity can be explained by contracted cattle. Just over three-quarters (76%) of the contracted throughput came from these loyal feedlots, while only one quarter (26%) of spot market throughput is purchased from loyal feedlots.

4 Explaining the division of feedlots

So far, we have seen that relationships in this data set are both exclusive and stable. While these findings do not preclude the exercise of market power, many unrelated factors can explain the relationships found. Indeed, we saw above that almost half of packer throughput (47%) is purchased from loyal feedlots, which suggests some dependence on regular suppliers. Next, we create a regression equation to explain the stability and exclusivity found in packer-feedlot relationships.[11]

4.1 estimating the bids

To consider the effect of prices offered from all packers on the proportion sold to a particular packer, we must estimate the value of unsuccessful bids. Jones, Schroeder, Mintert and Brazle (1992), Fawson, Bailey and Glover (1996), and Feuz (1999) suggest that bid prices are determined by quality characteristics of the cattle and the influences of supply and demand in the market. Thus, we divided our sample into two-week periods and estimated the effect on bids of various lot characteristics, distance from the feedlot to the packing plant and packing plant capacity, using data on accepted bids. We then use our parameter estimates to calculate fitted values for failed bids in each of the 33 two-week periods. The buyers' bid equations are given by:[12]

$$\begin{aligned} BID_{ijnt} &= \alpha_{0jt} + \beta_{j1t}DIST_{ij} + \beta_{j2t}DIST_{ij}^2 + \beta_{j3t}HEAD_n + \beta_{j4t}HEAD_n^2 \\ &+\beta_{j5t}FUTURES_{nk} + \sum_{m=2}^{5}\gamma_{jmt}YG\%_{mn} + \gamma_{j5t}CHOICE\% \\ &+\gamma_{j6t}MIXED_n + \gamma_{j7t}CARCASS_n + \gamma_{j8t}DAIRY_n \\ &+\gamma_{j9t}HEIFERS + \sum_{j=1}^{4}\delta_{jk}CAP_{jk} + \varepsilon_{ijnt} \qquad (1) \end{aligned}$$

where BID_{ijnt} is the bid accepted by the i^{th} feedlot ($i = 1, ..., 208$) from the j^{th}packer ($j = 1, 2, 3, 4$) for the n^{th} lot offered during the two-week period t ($t = 1, 2, ..., 33$), $DIST_{ij}$

[11] We consider only the 210 feedlots with a single exclusive relationship. Two of these feedlots were excluded because they did not sell until the last few days of the 15-month period and our regressions use two-week averages. Thus, our data set is a panel of 208 feedlots observed over 33 two-week periods.

[12] All variables except CAP_{jk} are included in the USDA, GIPSA data set used throughout this paper. CAP_{jk} specifies the percent of maximum capacity at which the packing plant is operating on a particular day. Maximum capacity was defined as the largest number of cattle slaughtered at the plant on a single day during the study period. Although cattle are not typically killed the same day they are purchased (priced) we assume that buyers can predict the effect of each purchase on slaughter date processing costs.

is the distance in linear miles from the i^{th} feedlot to the j^{th} packer, $HEAD$ is the number of head in the lot, $FUTURES_{nk}$ is the closing price for the nearby live cattle futures contract on the date when the n^{th} lot of cattle was killed (k), $YG\%_{mn}$ is the percentage of the cattle in the n^{th} lot falling into the m^{th} yield grade category, with yield grade 1 serving as the base ($m = 2, 3, 4, 5$). $CHOICE\%$ is the percentage of the lot that graded choice. $MIXED$ is a binary variable equal to 1 if the lot is a mixture of steers and heifers. $CARCASS$ is a binary variable equal to 1 if the lot was priced on a carcass basis. $DAIRY$ is a binary variable equal to 1 if the cattle were a dairy breed, and ε_{ijnt} is a random error term. We index each bid by feedlot (i), packer (j), lot id number (n) and two week period of sale (t).[13] Because bids for each packer are estimated separately, no packer dummy is necessary.

Table 3 gives the parameter estimates for equation 1. These results give average, maximum and minimum coefficients from the 31 regression equations (one for each two-week period). The average parameter estimates appear to be consistent with theory and results reported in other studies. The averge parameter estimates for $DIST$ and $DIST^2$ suggest that these packers price discriminate against distant sellers. This is not surprising given that competition for cattle is expected to be most keen when cattle are close to more than one packer. As lot size increases, price increases at a decreasing rate ($HEAD$ and $HEAD^2$).[14] The nearby live cattle futures contract ($FUTURES$) has a positive impact on cash prices, on average, indicating that local cash prices adjust at least partially to outside market information. Premiums are paid on average for yield grade 2 and 3 cattle, as well as cattle that will grade choice ($YG2\%, YG3\%, YG4\%, YG5\%$ and $CHOICE$). Selling cattle on a carcass basis ($CARCASS$) appears to reduce average price suggesting that live pricing is biased upward. Cattle sold in mixed lots of steers and heifers ($MIXED$), and

[13] The index n is distinct for each lot sold during the 15-month period, so that indexing BID by n alone is sufficient to identify it. We believe that adding j, k and t make the model easier to follow and thus err on the side of redundancy.

[14] Average parameter estimates suggest the optimum lot size is approximately 400 head, *ceterius paribus*.

in lots of only heifers ($HEIFERS$) are discounted as expected.

Insert Table 3 here

Ward (1993) and Purcell (1990) indicate that meat packing has large economies of scale. Consequently, packers benefit by operating plants at large scale. *Ceteris paribus* packers should pay higher prices when operating at low capacity, so that the coefficients on CAP_{jk}, the percentage of full capacity of the j^{th} packer on the n^{th} lot's slaughter date (day k) should be negative. While packer capacity may affect the proportion of spot market sales from feedlot i to packer j, it seems likely that this effect comes through prices. Thus, we include plant capacity here, rather than in the main regression discussed below.

Since capacity is endogenous, we instrument for it in equation 1 with $\widehat{CAP}_{jk}$:

$$\widehat{CAP}_{jk} = \lambda_0 + \sum_{j=1}^{4} \lambda_j CAP_{j,k-1} + \lambda_5 SAT_{jk} + \mu_{jk}$$

SAT is equal to 1 if the observation was for a Saturday, Sunday, or holiday. We replace CAP_{jk} with $\widehat{CAP}_{jk}$, and estimate equation 1 using ordinary least squares. Coefficients in equation 1 were replaced with their estimated values to calculate $\widehat{BID}_{ijxnt}$, the (estimated) bid the cattle might have received had they been sold to packer x ($x = \{1, 2, 3, 4\}$, $x \neq j$). Where $x = j$, $\widehat{BID}$ was the actual bid. $\widehat{BID}$ is restricted to be positive, since prices are positive. Additionally, $\widehat{BID}$ was restricted to be within two standard deviations of the mean bid, to control for the very few unreasonably large estimates. The average difference between successful and unsuccessful bids for each time period (t) was then calculated as follows:

$$\overline{PDIF}_{ijxt} = \overline{BID}_{ijt} - \overline{\widehat{BID}}_{ijxt} \tag{2}$$

where $\overline{PDIF}$ is the average price difference for two-week period t between what feedlot i

received from packer j and what it might have received from packer x.[15] The calculated price differences are omitted for reasons of confidentiality. We can report that estimated price differences are all positive and fairly small (less than $5 per cwt), none are statistically different from zero, and approximately half of actual prices exceed predicted prices.

4.2 factors influencing market stability and exclusivity

In a perfectly competitive market, feedlot operators should adjust sales based on the cash price that each packer offers ($\widehat{BID}_{ijxnt}$). However, transaction costs may affect sale proportions. Since these are not observable, we proxy for them and include estimated price differences in the following estimating equation:

$$\begin{aligned} PROP_{ijt} &= \phi_0 + \phi_1 PROP_{ijt-1} + \phi_2 IR_{ijt} + \phi_3 FLSIZE_{it} + \\ &\quad \phi_4 TOTLOT_t + \sum_{j=1}^{4} \sum_{x \neq j} \omega_{jx} D_j \overline{PDIF}_{ijxt} + \\ &\quad + \phi_5 PERSIST_{it} + \phi_6 CS_{ijt} + \sum_{j=1}^{3} \psi_j D_j + \xi_{ijt} \qquad (3) \end{aligned}$$

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} two-week period (only spot 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 IR_{ijt} is used to examine whether or not proportions tend to be "sticky" downward (reductions in proportions are smaller than increases in proportions

[15] Our time period is two weeks to allow enough degrees of freedom to estimate equation 1.

sold to a particular packer). This is similar to irreversibility as discussed in Ferris (1998). 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 asymetric downward, then IR_{ijt} will have a negative, significant coefficent.

$FLSIZE_{it}$ 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.

The variables $D_j\overline{PDIF}_{ijxt}$ represent the differences in actual prices paid by packer j and what could have been received from the three other packers. We expect the coefficients on these variables to be positive and significant. The D_js are dummy variables used to ensure that only price differences involving packer j are used to explain the proportion of feedlot output sold to packer j.

One possibility is that relationships are stable because price differences are small and feedlot operators fear retaliation if they reject a regular buyer's bid to accept a slightly higher bid from another buyer. To test for the possibility of retaliation (a transaction cost related to monitoring and enforcing implicit agreements) we included $PERSIST_{it}$, a binary variable set to one if any competing packer has offered \$3/cwt more for two or more consecutive (two-week) periods. If persistent price differences affect the proportion of sales going to a given packer, the coefficient on $PERSIST_{it}$ will be negative and significant.[16]

Based on the notion that retaliation is less costly for packers during periods of high supply we included the number of cattle offered for sale in the market each period, $TOTLOTS_t$. If feedlot operators fear retaliation from their primary customers for reducing their sales,

[16] $PDIF$ measures the difference between the actual purchase price and the estimated prices offered by competing packers. Thus, a negative $PDIF$ signifies higher offers that were not accepted.

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 $TOTLOTS_t$ 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. Summary statistics for our regressors are given in table 4.

Insert Table 4 here

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 was used to estimate equation 3, and parameter estimates are reported in table 5.

Insert Table 5 here

Our results support the notion that relationships between feedlots and packers are quite stable. The coefficient for lagged spot market sales ($PROP_{ijt-1}$) is significantly different than zero and positive. Upward adjustments in proportions from one time period to the next tend to be larger than downward adjustments (IR_{ijt}). This implies one-way rigidity in these relationships. The coefficient for feedlot size ($FLSIZE_{it}$) is positive and significantly different than zero, suggesting that larger feedlots tend to sell larger proportions of their cattle to packers. It appears that economies of size exist in the establishment and maintenance of relationships. Surprisingly, a larger proportion of contract sales from feedlot i to packer j (CS_{ijt}) reduces the portion of spot market transactions between 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.

The results on price differences are mixed, with all estimates being quite small, and half not significantly different from zero. These coefficients should be positive and significant if the market is competitive. Consistent with our results above, this market does not appear to be perfectly competitive, since differences in offered prices do not have a strong relationship with shifts in proportions sold to each packer.

Even persistent price differences lead to an insignificant adjustment in proportions sold to each packer, as the coefficient on $PERSIST_{it}$ is not significantly different from zero. Possible reasons for these results include transaction costs that make pursuing relatively small price differences unprofitable or the threat of retaliation that makes small short-run payoffs unprofitable. However, our results provide limited statistical evidence that the proportions feedlots sell to individual packers change significantly during periods of relatively heavy supply, as the coefficient on the size of the market ($TOTLOTS_t$) is not significantly different from zero.

Our results indicate that neither current price nor persistent price differences influence the proportion of sales between feedlots and each packing plant (as they would in a perfectly competitive market). Instead, previous spot market sales, the size of the feedlot and the presence (or absence) of a contracting relationship appear to affect the proportion of spot market sales. The results imply that transaction costs are a major reason why feedlots and packers establish and maintain stable relationships.[17] While it is reasonable to conclude

[17] This is supported by the residuals of the entire regression. Our adjusted R^2 indicates that approximately 75% of the variation in proportions sold to a particular packer is explained by the variables included.

that this market departs from the standard perfectly competitive model (where price is the only determinant of market exchanges), this may be because the perfectly competitive model is not well suited to addressing issues of relationship stability and transaction costs. Additionally, we cannot necessarily conclude that packers are taking advantage of their position, since reducing transaction costs may benefit both the feedlot and the packer.

5 Conclusion and Extensions

This paper suggests that alternative measures of market power are warranted in study of the beef packing industry. We propose two measures based on easily quantifiable, albeit not readily available, data. Inasmuch as our evidence does not rely on hard-to-measure variables, it may allow for more definitive conclusions regarding whether concern about the structure of the beef packing market is justified.

Our first measure classifies packer-feedlot relationships as exclusive when a feedlot sells an unusually large proportion of its output to a single packer. In a competitive market observed over time, feedlots should sell approximately the same proportions to all packers in the area. Feedlots which sell more to a particular packer are said to have an exclusive relationship with that packer. Over half of the feedlots in our sample have an exclusive relationship with a single packer. Our second measure is more stringent, as it uses the criterion of *all* sales going to the primary customer. We divide our data set into two-week periods, and examine the percentage of two-week periods a feedlot with a single exclusive relationship sold *only* to its primary custmer. Again, our results suggest that the market for fed beef which we examined is not perfectly competitive, since over half of all feedlots with a single exclusive relationship *always* sell to their primary customer exclusively. However, this dependence may be mutual, as packers purchase just under half of their throughput from these feedlots.

Of course packers may have exclusive relationships with feedlots for many reasons not related to the exercise of market power. In the paper's third section, we discuss some of these reasons, and develop a regression model designed to control for many of them. Variables proxying for transaction costs explain much of the variation in 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 are much larger than decreases in proportions sold) have the largest influence on spot market proportions. Price differences, even persistent price differences do not appear to have a large or significant effect on how much a feedlot sells to each packer. However, our analysis relied on estimated bids. Additional data on failed bids might be helpful in resolving the relationship between price differences and proportions sold. Feedlots may benefit as much as packers do from the stability and exclusivity found in relationships.

It would be interesting to use these measures in other industries, to examine alternative ways that firms exercise market power. These measures have the advantage of being straightforward and simple to calculate, when appropriate data exists. In this sense, they allow one to draw conclusions about market power without being subject to hard-to-evaluate elasticity estimates from outside the model. They are thus useful additions to the set of tools used to examine market power.

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Table 1: Exclusive Relationships Between Feedlots and Packers

Entire Market

All Feedlots (335), 62.9 Miles	# Feedlots	% Feedlots	**Excluding Small Feedlots (279), 62.9 Miles**	# Feedlots	% Feedlots
With Smoothing			**With Smoothing**		
No Packing Plants	42	12.54	No Packing Plants	33	11.83
One Packing Plant	209	62.39	One Packing Plant	162	58.06
Two Packing Plants	76	22.69	Two Packing Plants	76	27.24
Three Packing Plants	8	2.39	Three Packing Plants	8	2.87
No Smoothing			**No Smoothing**		
No Packing Plants	4	1.19	No Packing Plants	1	0.36
One Packing Plant	295	88.06	One Packing Plant	242	86.74
Two Packing Plants	36	10.75	Two Packing Plants	36	12.90
Three Packing Plants	0	0.00	Three Packing Plants	0	0.00
# Head, No Smoothing			**# Head, No Smoothing**		
No Packing Plants	0	0.00	No Packing Plants	0	0.00
One Packing Plant	263	78.51	One Packing Plant	208	74.55
Two Packing Plants	68	20.30	Two Packing Plants	67	24.01
Three Packing Plants	4	1.19	Three Packing Plants	4	1.43

Table 1: Exclusive Relationships Between Feedlots and Packers

Spot Market

All Feedlots (311), 62.9 Miles	# Feedlots	% Feedlots	**Excluding Small Feedlots (260), 62.9 Miles**	# Feedlots	% Feedlots
With Smoothing			**With Smoothing**		
No Packing Plants	51	16.40	No Packing Plants	34	13.08
One Packing Plant	183	58.84	One Packing Plant	149	57.31
Two Packing Plants	66	21.22	Two Packing Plants	66	25.38
Three Packing Plants	11	3.54	Three Packing Plants	11	4.23
No Smoothing			**No Smoothing**		
No Packing Plants	4	1.29	No Packing Plants	1	0.38
One Packing Plant	266	85.53	One Packing Plant	218	83.85
Two Packing Plants	41	13.18	Two Packing Plants	41	15.77
Three Packing Plants	0	0.00	Three Packing Plants	0	0.00
# Head, No Smoothing			**# Head, No Smoothing**		
No Packing Plants	0	0.00	No Packing Plants	0	0.00
One Packing Plant	239	76.85	One Packing Plant	189	72.69
Two Packing Plants	69	22.19	Two Packing Plants	68	26.15
Three Packing Plants	3	0.96	Three Packing Plants	3	1.15

Table 1: Exclusive Relationships Between Feedlots and Packers

Contract Market

All Feedlots (150), 62.9 miles	# Feedlots	% Feedlots	**Excluding Small Feedlots (145), 62.9 Miles**	# Feedlots	% Feedlots
With Smoothing			**With Smoothing**		
No Packing Plants	27	18.00	No Packing Plants	24	16.55
One Packing Plant	83	55.33	One Packing Plant	81	55.86
Two Packing Plants	31	20.67	Two Packing Plants	31	21.38
Three Packing Plants	9	6.00	Three Packing Plants	9	6.21
No Smoothing			**No Smoothing**		
No Packing Plants	2	1.33	No Packing Plants	2	1.38
One Packing Plant	137	91.33	One Packing Plant	132	91.03
Two Packing Plants	11	7.33	Two Packing Plants	11	7.59
Three Packing Plants	0	0.00	Three Packing Plants	0	0.00
# Head, No Smoothing			**# Head, No Smoothing**		
No Packing Plants	0	0.00	No Packing Plants	0	0.00
One Packing Plant	135	90.00	One Packing Plant	130	89.66
Two Packing Plants	15	10.00	Two Packing Plants	15	10.34
Three Packing Plants	0	0.00	Three Packing Plants	0	0.00

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%

Table 3. Statistics for Parameter Estimates for Bid Model (Equation (1))

Variable	Avg Parameter Estimate	% Significant at 10%	Minimum	Maximum
Intercept	54.375	50.00	-1808.660	1830.070
DIST	$7.490E^{-5}$	46.21	-0.0001	0.0001
$DIST^2$	$-2.020E^{-6}$	42.42	-0.0001	0.0001
HEAD	0.0020	24.24	-0.0096	0.0151
$HEAD^2$	$-2.328E^{-6}$	15.91	$-2.080E^{-5}$	$1.480E^{-5}$
FUTURES	0.1957	56.06	-2.9580	5.2805
YG2%	0.0066	35.61	-0.1075	0.0946
YG3%	0.0098	35.61	-0.0588	0.0842
YG4%	-0.0189	23.48	-0.2730	0.1881
YG5%	-0.1402	13.74	-6.0071	2.6470
CHOICE%	0.0104	39.39	-0.0251	0.0587
MIXED	-0.4410	35.94	-3.4840	1.8880
CARCASS	-1.3780	73.85	-6.2240	2.8260
DAIRY	-1.8760	95.45	-9.0460	0.0000
HEIFERS	-0.2011	28.79	-1.9610	0.8727
Adjusted R^2:	Maximum	0.7792	Average	0.4725
	Minimum	0.0530	Median	0.5034

The percentage of capacity at which each plant was operating (*CAP1* through *CAP4*) was also included in this regression. Coefficients on these variables are not reported to preserve confidentiality. Some variables, such as Dairy, were not present each time period. Percentages are more telling in these situations.

Table 4: Summary Statistics for Regressors Other Than Price

Variable	Mean	Std Deviation	Minimum	Maximum
Irreversibility	0.18	0.39	0	1
Lagged Spot Market Sales	0.25	0.38	0	1
Size of Feedlot	7.33	8.22	1	72
Size of Market	892.00	78.61	761	1073
Persistent Price Differences	0.05	0.22	0	1
Percent Contract Sales	0.06	0.22	0	1

Number of observations for all variables = 15,324

Table 5: Regression Results, Dependent Variable = % Spot Market Sales to Packer

Variable		Price Differences	
Intercept	-0.0342 (0.1181)	pdif1	0.0008 (0.0005)
Irreversibility (IR_{ijt})	-0.4209 (0.0057)**	pdif2	0.0003 (0.0004)
Lagged Spot Market Sales ($PROP_{ijt-1}$)	0.4282 (0.0081)**	pdif3	0.0003 (0.0005)
Size of Feedlot ($FLSIZE_{it}$)	0.0012 (0.0004)**	pdif4	-6.596 x E^{-5} (0.0005)
Size of Market ($TOTLOTS_t$)	2.995 x E^{-5} (2.136 x E^{-5})	pdif5	0.0013 (0.0004)**
Persistence ($PERSIST_{it}$)	-0.0099 (0.0083)	pdif6	0.0020 (0.0005)**
Percent Contract Sales (CS_{ijt})	-0.0205 (0.0098)*	pdif7	0.0008 (0.0005)‡
		pdif8	.0013 (0.0005)**
		pdif9	0.0010 (0.0005)*
		pdif10	0.0004 (0.0005)
		pdif11	0.0011 (0.0005)*
Adjusted R^2	0.73	pdif12	0.0019 (0.0004)**

Coefficients on packer-specific variables (D_j) are not reported to preserve confidentiality
Hausman test statistic for random effects: 754.81
F-test statistic for fixed effects: 9.08
Standard errors given in parentheses
‡significant at 10% *significant at 5% **significant at 1%