Title: Estimated Impact of Non-Price Coordination of Fed Cattle Purchases on Meat Packer Processing Costs

Authors:

John D. Anderson
Assistant Extension Professor.
412 Agr. Engineering #2
Dept. of Agr. Econ.
University of Kentucky
Lexington, KY 40546
Phone: (606) 257-7273
Fax: (606) 323-1913
Email: janderso@ca.uky.edu

James N. Trapp
Regents Professor
317 Ag Hall
Dept. of Agr. Econ.
Oklahoma State University
Stillwater, OK 74078
Phone: (405) 744-6171
Fax: (405) 744-8210
Email: jntrapp@okway.okstate.edu

Abstract:
Stochastic simulation of daily slaughter level was used in conjunction with estimated packing plant cost curves to assess potential reductions in processing costs due to improved vertical coordination between feedlots and packing plants. Results indicate that processing cost reductions of $1 to $5 per head are possible.

Key words: fed cattle, processing cost, stochastic simulation, vertical coordination

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Introduction

Despite dramatic changes in the beef industry over the past 20 years, coordination between the various levels of the industry is still primarily achieved by the price system. Increasingly, this vertical coordination method is in contrast to those that have evolved in the pork and poultry industries. In these industries, non-price forms of vertical coordination have come to dominate. Because of the adversarial relationship between beef cattle feeders and packers, coordination between these two levels of the beef industry by price only may well exhibit significant inefficiencies. Any existing inefficiency between these two production phases of the beef industry will reduce the overall competitiveness of the beef industry relative to its closest competitors--poultry and pork. Competitive pressures from poultry and pork are forcing the beef industry to look for ways to increase its competitiveness. Improved coordination efficiency between packers and feeders may offer significant potential to do this. This study will investigate the potential cost reduction capable of being achieved by beef packing plants through improved supply coordination with feedlots.

In addition to these applied considerations, a study of vertical coordination in the fed cattle market also has compelling theoretical justification. Since economists rarely have the opportunity to measure performance criteria for various forms of vertically coordinated structures, empirical estimates of the value of coordination are noticeably absent in the literature. Similarly, there are no estimates of whether one set of parties (buyers or sellers) or both gain or lose, and how much one set gains or loses relative to the other (Den Ouden et al.).

The packing sector of the beef industry would seem to have particularly strong incentives to adopt non-price methods of coordinating their purchases of fed cattle. Koontz and Purcell note the strong incentives that packers have to operate at full capacity due to their relatively high
ratios of fixed to variable costs. This observation is consistent with the vertical coordination
theory outlined by a number of authors. For example, Frank and Henderson cite asset specificity
as a major incentive for vertical coordination. Their work builds on the theory of Williamson,
who divides assets into three categories: nonspecific, mixed, and idiosyncratic. Idiosyncratic
investments have very specific uses while nonspecific assets can easily be put to a number of
different uses. Mixed investments fall on a continuum between these two extremes. Williamson
argues that contracting will be the cost minimizing method of coordination when recurring
transactions occur between participants whose investments are mixed. As the characterization of
investments becomes more idiosyncratic, direct ownership (vertical integration) becomes the
cost minimizing coordination method.

Williamson’s focus on the characterization of the productive assets in an industry is
particularly relevant to a discussion of the fed cattle market. Over the past 20 years, packing
firms have invested in large plants that must run at full capacity or face production cost
increases. One logical strategy for them to employ in their efforts to operate at capacity is the
coordination of fed cattle purchases through contracting with feedlots or through the direct
ownership of cattle on feed. While economic theory identifies the incentives for these strategies
on the part of packers, it is not certain how much, if anything, packers stand to gain in terms of
cost savings from the adoption of such strategies. In other words, a quantitative measure of the
benefits of non-price coordination between the feeding/packing sector is needed to augment the
qualitative statements that have been made regarding such coordination.

The objective of this research is to determine the potential reductions in processing costs
that may be expected to arise from more efficient coordination of daily marketing/purchasing
volumes between cattle feeders and meatpackers. To do this, summary statistics of daily
slaughter rates for 35 packers were obtained from the USDA’s Grain Inspection Packers and Stockyards Administration (GIPSA). This information is used to develop a stochastic simulation model reflective of existing daily slaughter levels and volatility. Stochastic simulation results from the model are used to estimate the potential reductions in processing costs possible with alternative non-price vertical coordination methods designed to optimize and stabilize the daily slaughter rates of packing plants.

Industry Slaughter Capacity Utilization Rates and Volatility

Results of a study by Anderson et al. using the Fed Cattle Market Simulator (FCMS) suggest that it is worth approximately $3 per head to the packing plant industry to be able to stabilize slaughter volume at each plant’s optimal volume. However, their study bases its conclusion on experimental data rather than actual industry data. To investigate the accuracy of their estimate, a set of actual industry summary statistics on daily slaughter rates were obtained from (GIPSA). During a previous study on packer concentration, GIPSA collected daily slaughter volumes for all plants where fed cattle slaughter constituted 80% or more of total slaughter for the period from April 5, 1992 to April 3, 1993. The data set contained 9,145 observations from 35 packing plants. GIPSA did not have documentation of the slaughter capacity rates of the plants in the data set. Also, due to confidentiality restrictions, GIPSA could not release the actual data or the identity of the plants included in the data set. However, GIPSA was willing and able to provide summary statistics of the data set. In order to estimate the physical capacity of plants in the data set, it was requested that GIPSA compute the average of the highest 15 slaughter days for each plant during the yearlong period covered by the data. It
was further requested that this value then be used to form a daily slaughter capacity utilization index of the following form:

\[
SCUI_{tj} = \left(\frac{SLGVOL_{tj}}{AVG15_j}\right) \times 100
\]

where \( SCUI_{tj} \) is the slaughter capacity utilization index for plant \( j \) on day \( t \); \( SLGVOL_{tj} \) is the reported slaughter volume for plant \( j \) on day \( t \); and \( AVG15_j \) is the average of the highest 15 days of slaughter volume for plant \( j \).

The first column in table 1 provides summary statistics for the entire GIPSA data set. The second column reports the same statistics, but considers the data subset defined by observations with a \( SCUI \) equal to or greater than 0.66. This data set will be referred to hereafter as the “truncated” data set. The data was divided in this manner in an attempt to separate days where a sharp drop in slaughter occurred due to factors other than volatility in cattle procurement (i.e., any mechanical or maintenance problem that caused the suspension of one or more shifts during the day). Stabilizing cattle supplies with vertical coordination strategies would not eliminate capacity utilization volatility due to such problems.

Several points bear emphasis with regard to the data reported in Table 1. First, the data are skewed (i.e., the third moment is significantly large and negative). Second, the median is above the mean. Figure 1 is a histogram of the data set. It illustrates the skew of the data set very well. Related to the second point, the mean and mode of the data set are well below an index value of 100, thus indicating that plants were generally not operating close to their demonstrated physical limit during the data period. One reason plants may not have been utilizing their full physical capacity was that the data period used was near the bottom of the cattle cycle, thus making the procurement of an adequate/optimal number of cattle more difficult.
Also, it is possible that it is not economically optimal to sustain a plant’s operation for a long period of time near its physical maximum rate. The cost to the industry implied by the volatility in slaughter rates described by the GIPSA data was estimated using stochastic simulation. An empirical distribution based on the truncated GIPSA histogram data was used to generate random slaughter capacity utilization rates. 1,000 random plant capacity utilization rates were simulated from the empirical distribution for each simulation done. The slaughter cost associated with each random capacity utilization rate was evaluated using the cost curve figures in Table 2. These cost curves were derived from work done by Duewer and Nelson and are believed to be the most representative figures of the industry available. Linear interpolation was used to evaluate costs for random capacity figures between those reported in the table.

The mean of the 1,000 cost figures simulated using the truncated data set was $91.67. Comparing this cost level to the least-cost processing cost specified, which was $87.50/head for operation of a plant at 100% of capacity, yields a difference of $4.17. This difference is deduced to be the typical cost inefficiency experienced by slaughter plants during the data period covered by the GIPSA data set that is attributable to non-optimal daily slaughter rates. This inefficiency amount can be separated into two parts: a) the cost of operating at an average capacity below the optimal capacity; and b) the cost of volatility around that average level. The simulated mean slaughter capacity utilization rate was 88.5%, which is very close to the reported 88.09%. The processing cost reported in Table 4 that is associated with a capacity utilization rate of 88.5% (derived by linear interpolation) is $90.64. The difference between $90.64 and $87.50 (the least cost-value associated with 100% capacity utilization) is $3.14. Thus it is deduced that the majority of the total $4.17 cost inefficiency found is due to the average plant utilization rate
being about 12% below the assumed least-cost utilization rate of 100. This leaves $1.03 of cost inefficiency ($4.17 - $3.14) being attributed to instability/variance around the mean capacity utilization rate.

The $1.03 of inefficiency attributed to non-constant slaughter utilization rates can intuitively be explained as arising from two factors: a) the cost curve rises more rapidly below the capacity of 88% than it falls above that capacity; and b) the distribution from which the random capacity utilization rates were drawn is skewed. The first condition causes random deviations that fall below the mean capacity utilization rate to be penalized by added costs more than random deviations that fall above the mean are rewarded with reduced costs. The effect of the skew in the data is mixed. The fact that the median is above the average implies that slightly more observations will be randomly drawn above the mean than below, thus causing more decreases in cost relative to the cost at the mean than increases. However the shape of the skew also implies that observation drawn below the mean will typically have larger deviations from the mean and thus draw bigger cost penalties compared to the cost reductions given to typically smaller deviations from the mean for random observations above the mean.

The assumption that a plant’s optimal capacity is equal to the average of its 15 largest slaughter days, while logical is arbitrary. A sensitivity test can be conducted to determine the effect of this assumption on the cost inefficiency estimates made. Specifically the question to be answered by this test is: “What is the implication for the inefficiency cost estimates made if it is assumed the lowest cost point of operation is at a volume which is 95%, 90%, etc. of the average found for the 15 highest volume slaughter days?” Separate simulations can be conducted which show that shifting the low point of the cost curve down 5 index points has the same effect on estimated inefficiency costs as shifting the distribution of slaughter capacity utilization rates up 5
index points. What is critical in this analysis (and in reality) is the difference between the simulated (actual) random slaughter capacity rates and the assumed low cost slaughter capacity utilization rate.

This analysis can not be certain that the mismatch between the assumed optimal slaughter rate and the actual industry slaughter capacity utilization rate (as calculated from the GIPSA data) is due to: a) low supplies of cattle during the data period; b) an overestimate of the plant’s optimal slaughter rate; or c) some combination of both of these factors. To conduct a sensitivity test of this question the assumed low cost volume index was adjusted in increments of 5 points between 75 and 105. Using the truncated GIPSA data set previously described this results in ratios between the assumed optimal capacity utilization rate and the mean of the simulated capacity utilization rate that range from about 0.84 to 1.17. The results of these sensitivity tests are reported in Table 3.

The estimated inefficiency costs discussed above, i.e. the estimated costs when the optimal slaughter capacity utilization rate index value is assumed to be 100, are presented in the second line of Table 3. The other lines report the result of alternative assumptions about the optimal/low cost slaughter capacity utilization rate.

Two patterns in the values comprising Table 3 provide insight into the nature of the cost inefficiency caused by low and volatile slaughter capacity utilization rates. First, the inefficiency cost from non-optimal average slaughter capacity utilization rate approaches zero as the assumed “Optimal Slaughter Capacity Utilization Rate” (column #2) approaches the actual average slaughter capacity utilization rate of the two data sets defined here, which in turn results in the ratio reported in column #1 approaching 1.00. It should also be noted that the cost increases associated with under-utilizing a plant’s capacity rise faster with increasing levels of under-
utilization than they do with increasing levels of over-utilization. This is the case because the
cost curve remains relatively flat beyond its low cost volume. The second general observation is
that the cost inefficiencies generated from unstable slaughter levels appear to peak when plants
are operating at a little less than 90% of the specified Optimal Slaughter Capacity Utilization
Rate. This follows from the fact that with a given random distribution of slaughter capacity
utilization levels, the greatest cost of instability occurs at a point on the cost curve where the
second derivative of the cost curve is the largest (i.e., where the curve is changing slope the
fastest). In the case of the cost curve developed here this occurs at approximately 90% of full
utilization. As explained above, with extreme curvature of the cost curve, random low values
drawn from the slaughter utilization rate distribution are penalized more than random high values
are rewarded. Intuitively, it seems that the largest cost of instability would occur when the
average slaughter level was equal to the capacity utilization rate at the low point on the cost
curve since deviations in either direction would result in higher costs. However the cost curve
derived from Duewer and Nelson’s work is very flat beyond its low point and is also relatively
flat just before its low point. Hence the majority of the deviations that occur in this area do not
effect cost by a magnitude which would result in large changes in cost. This is especially the
case with positive deviations above the low cost capacity utilization level.

The question that arises now is, of all the values presented in Table 3, which is the most
accurate estimate of actual industry costs to packing plants due to non-optimal and unstable
slaughter volumes? The answer is the typical economist answer of “it depends” and it probably
varies over time. The period over which the GIPSA data were collected was one in which the
slaughter level was about 1% above the previous cyclical low in slaughter numbers and about
12% below the previous cyclical high in slaughter numbers. Considering this fact, and
assuming the industry’s aggregate slaughter capacity does not change over a cattle cycle, it can be inferred that over the course of the cattle cycle, slaughter plants would typically operate 5 percentage points closer to their physical capacity limit than they did during the data period in question. Given that the average capacity utilization rate in the truncated GIPSA data was about 88%, this would imply an average capacity utilization rate over an entire cycle of about 93%. Given these assumptions, and the assumption that the least-cost level of operation is at a plant’s physical maximum rate, row three of Table 3 appears uniquely relevant. It is for a plant operating at 93% of its optimal capacity. The indicated total inefficiency cost is $2.19/head with $0.87 of that cost due to slaughter volatility and $1.32 due to a less-than-optimal volume. This would appear to be the most representative estimate of the long-term cost to the industry of non-optimal and volatile daily slaughter rates. It is important however to recognize that total cost inefficiency likely changes dramatically over the cattle cycle. During low points in the cattle numbers cycle, the plant utilization rate associated with the mean of the truncated data set could drop to around 87%. This would cause the inefficiency cost to rise to almost $5/head. During the peak of the cattle numbers cycle the plant utilization rate associated with the truncated data set mean could rise to about 99%, thus causing the inefficiency cost to drop to less than $1/head.

A potential compounding effect on the magnitude of the change in cost inefficiency hypothesized for slaughter plants over a cattle cycle is the expectation that when cattle numbers are large, cattle slaughter rates will not only be nearer to optimal plant capacities, but also will probably be more stable. The critical implication that follows is that one of the reasons that packing plants will be more aggressive bidders for both cash cattle and contracted cattle when cattle supplies are short, is to avoid processing cost inefficiencies from less-than-optimal and unstable volume.
Summary and Conclusions

A stochastic simulation designed to measure the effect of fed cattle supply variability on packer profits was performed using an empirical distribution of plant capacity utilization data that was derived from data obtained from GIPSA. Results indicate that in the long-run (i.e., over an entire cattle cycle) packers probably lose just over $2/head to cattle supply variability and capacity under-utilization. This figure likely varies a great deal over the course of a cattle cycle—from approximately $5/head when cattle numbers are near their cyclical low, to only $1/head when cattle numbers are near their cyclical high. While the magnitude of this number may seem insignificant relative to the total value of the animal being processed, it is not economically insignificant with regard to typical feedlot and/or packer profits per head. Data on packer profits are highly confidential and not readily available. However, feedlot profit records from custom feeding operations are readily available. According to a study by Trapp, they indicate average feeding profits per head over a complete cattle cycle (i.e., a 10-year period) can be expected to be approximately $10/head. Assuming that the benefits of improved vertical coordination would be shared between packers and feeders and that packer profits per head are comparable to feeder profits, a $1 to $5 per head increase in profits would appear to be economically significant to both packers and feeders.

Current efforts by a limited number of feedlots and packers to develop non-price vertical coordination schemes appear to indicate the potential benefits of such coordination efforts are worth the cost of developing the coordination. However, the magnitude of the potential monetary benefits estimated here does not imply that improved packer/feeder coordination would increase beef industry competitiveness enough to greatly enhance the industry’s meat market share relative to pork and poultry.
### Table 1. Statistical Summary of GIPSA Reported Plant Utilization Index Data

<table>
<thead>
<tr>
<th>Data Item</th>
<th>All Observations</th>
<th>Observations With SCUI &gt; .66</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Plants</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>Number of Observations</td>
<td>9,145</td>
<td>8,293</td>
</tr>
<tr>
<td>Number of Saturday Observations</td>
<td>450</td>
<td>256</td>
</tr>
<tr>
<td>Mean of $SCUI$</td>
<td>84.92</td>
<td>88.09</td>
</tr>
<tr>
<td>Median of $SCUI$</td>
<td>88.63</td>
<td>89.79</td>
</tr>
<tr>
<td>Variance of $SCUI$</td>
<td>173.28</td>
<td>71.78</td>
</tr>
<tr>
<td>Third Moment of $SCUI$</td>
<td>-3,436.81</td>
<td>-292.23</td>
</tr>
<tr>
<td>Fourth Moment of $SCUI$</td>
<td>183,420.34</td>
<td>19,293.69</td>
</tr>
</tbody>
</table>

### Table 2. Combined Killing and Fabrication Costs/Head for Alternative Slaughter Rates

<table>
<thead>
<tr>
<th>Slaughter Rate as a Percent of Physical Plant Capacity</th>
<th>Killing and Fabrication Costs/Head</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>$169.69</td>
</tr>
<tr>
<td>50</td>
<td>$138.13</td>
</tr>
<tr>
<td>60</td>
<td>$117.81</td>
</tr>
<tr>
<td>70</td>
<td>$105.79</td>
</tr>
<tr>
<td>80</td>
<td>$ 96.61</td>
</tr>
<tr>
<td>90</td>
<td>$ 89.59</td>
</tr>
<tr>
<td>100</td>
<td>$ 87.50</td>
</tr>
<tr>
<td>110</td>
<td>$ 87.61</td>
</tr>
<tr>
<td>120</td>
<td>$ 87.74</td>
</tr>
</tbody>
</table>
Table 3. Simulated Cost Inefficiencies From Non-Optimal Average Daily Slaughter Rates and Variable Daily Slaughter Rates

<table>
<thead>
<tr>
<th>Ratio of Actual vs. Optimal Capacity Utilization Rate (1)</th>
<th>Optimal Capacity Utilization Rate (2)</th>
<th>Total Cost Inefficiency (3)</th>
<th>Inefficiency From Instability (4)</th>
<th>Inefficiency From Non-optimal Utilization Rates (5)</th>
<th>Simulated Mean (6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.84</td>
<td>105</td>
<td>$6.73</td>
<td>$0.31</td>
<td>$6.42</td>
<td>88.8</td>
</tr>
<tr>
<td>0.88</td>
<td>100</td>
<td>$4.17</td>
<td>$1.03</td>
<td>$3.14</td>
<td>88.5</td>
</tr>
<tr>
<td>0.93</td>
<td>95</td>
<td>$2.19</td>
<td>$0.87</td>
<td>$1.32</td>
<td>88.7</td>
</tr>
<tr>
<td>0.98</td>
<td>90</td>
<td>$1.09</td>
<td>$0.77</td>
<td>$0.32</td>
<td>88.5</td>
</tr>
<tr>
<td>1.04</td>
<td>85</td>
<td>$0.50</td>
<td>$0.46</td>
<td>$0.04</td>
<td>88.7</td>
</tr>
<tr>
<td>1.10</td>
<td>80</td>
<td>$0.26</td>
<td>$0.16</td>
<td>$0.10</td>
<td>88.5</td>
</tr>
<tr>
<td>1.17</td>
<td>75</td>
<td>$0.20</td>
<td>$0.04</td>
<td>$0.16</td>
<td>88.7</td>
</tr>
<tr>
<td>Avg. 0.96</td>
<td>92.5</td>
<td>$2.49</td>
<td>$0.60</td>
<td>$1.89</td>
<td>88.6</td>
</tr>
</tbody>
</table>

Figure 1. Distribution of daily slaughter rates as a percent of physical plant capacity
References


