Impacts of Alternative Marketing Agreement Cattle Procurement Volumes on Packer Costs: Evidence from Plant-Level P&L Data

by

Stephen R. Koontz, Mary K. Muth, and John D. Lawrence

Impacts of Alternative Marketing Agreement Cattle Procurement Volumes on Packer Costs: Evidence from Plant-Level P&L Data

Stephen R. Koontz, Mary K. Muth, & John D. Lawrence*

Paper presented at the NCCC-134 Conference on Applied Commodity Price Analysis, Forecasting, and Market Risk Management
Chicago, Illinois, April 16-17, 2007

* Koontz is Associate Professor in the Department of Agricultural and Resource Economics at Colorado State University, Muth is Director, Food and Agricultural Policy Research Program, RTI International, and Lawrence is Professor in the Department of Economics and Director of the Iowa Beef Center at Iowa State University.

Impacts of Alternative Marketing Agreement Cattle Procurement Volumes on Packer Costs: Evidence from Plant-Level P&L Data

It has been argued that access to captive supply cattle improve the economic efficiency of beef packing facilities. However, this argument has not been subject to hypothesis testing. This work models the cost efficiencies associated with captive supplies or cattle we refer to as being sourced through alternative marketing agreements (AMAs). We find that slaughter and processing costs are lower ceteris paribus for AMA cattle than for cash market cattle. We find that plants that slaughter cattle from AMA sources operate at higher monthly volumes ceteris paribus and lower average costs per head. And we find that plants that slaughter cattle from AMA sources have more predictable volumes ceteris paribus and have lower average costs per head. If AMAs were limited or prohibited then packing industry efficiency would be negatively impacted and that fed cattle prices would be negatively impacted.

Introduction

Captive supplies are a contentious issue with some cattle industry members. As a result policy makers have introduced a number of Congressional bills to limit the use of these alternative marketing arrangements (AMAs) over the past five years. AMAs are marketing alternatives that do not involve the use of cash markets. In the cattle industry, AMAs include forward contracts, packer-owned cattle, and marketing agreements. The most well-known of these bills was the Johnson Amendment to the 2002 Farm Bill. The bill would have prohibited the use of AMAs.

As a compromise to the proposed legislation, in 2003 Congress mandated and funded a study of AMAs. Prior research on the impact of captive supplies includes Elam (1992), Schroeder et al. (1993), Azzam (1998), Ward, Koontz and Schroeder (1998), and Schroeder and Azzam (1999 and 2003). A limitation to prior research is that only the costs associated with AMAs were measured. These studies measured the market power associated with AMA use. The mandated study was to include a comprehensive examination of costs and benefits to AMA use. The resulting GIPSA Livestock and Meat Marketing Study (LMMS) was completed in early 2007. The research reported in this paper examines a specific benefit to the use of AMAs.

One justification to the use of AMAs is that these supplies of animals allow more efficient use of meatpacking facilities. AMAs may permit the packing plant to be operated at a lower cost because AMA volumes can be better anticipated and better matched with necessary other inputs. AMAs may also permit the packing plant to be operated at higher volumes or at optimal volumes – volumes whereby the slaughter and processing costs are the lowest over the operating range. Last, AMAs may permit the packing plant to be operated at more consistent volumes. More variable slaughter and processing volumes and U-shaped average cost function result in higher costs than less variable volumes. While all of these arguments have sound economic logic and have long been recognized as possible (see, e.g., Purcell (1979) and Feuz et al. (2002)), these agruments are hypotheses and have not been tested with real world data.

One element of the Livestock and Meat Marketing Study evolved an analysis of packer profit and loss (P&L) data. The objective was to test the hypotheses above with data that packers use for internal operations management. Are costs that are observed in packer P&Ls lower with higher volumes of AMA cattle? This paper reports the results of those models and tests.

Conceptual Model

The underlying modeling framework is to explain the level of average slaughter and processing costs. The margin between beef prices received and cattle prices paid must cover average total economic costs of slaughter and processing in the long run. If costs are higher for cash market cattle than for AMA cattle then eliminating the availability of AMA cattle to the packing industry will result in higher long-run costs. Increases in costs will result in direct decreases in fed cattle prices paid.

Much marketing margin research estimates the supply and demand for wholesale beef and the supply and demand for fed cattle (see, e.g., Wohlgenant (1989)). Equilibrium margins can then be inferred and simulated from these relationships. Further, supply responses and changes in market quantities can be calculated from the functional relationships.

Our approach is more simplistic. Profit and loss data are well-known to be problematic especially for the estimation of marginal relationships (see French (1977)). Accounting data simply do not represent marginal costs and marginal returns well. However, the first strength of P&L data are that it is real. It is want firms observe through operations and it is what firms use in the making of management decisions. Second, average cost relationships can be well-inferred from P&L data and average costs must be covered by margins in the long-run. Increases in average costs imply prices paid for other inputs must decline.

Description of Profit and Loss Statement Data

In this section, the P&L data obtained from the largest beef packing firms are described. The P&L data are by plant, within each firm that slaughters and processes fed beef cattle. All results presented are aggregated across plants and firms included in the analysis. Thus, although results specific to any individual packer are not presented, all analyses were conducted on P&L data from individual plants.

This is the first economic analysis of P&L data from the beef packing industry that has been conducted as part of an industry study. GIPSA has collected packer P&L data but only reports the data aggregated across firms. Therefore, it is not possible to examine individual firm performance or individual plant performance. This is the first study to examine plants and firm performance with the same information that firm managers have.

The volume of head slaughtered and processed by the firms included in the analysis for the October 2002 through March 2005 period was slightly more than 80% of USDA-reported federally inspected steer and heifer slaughter. All of the firms included in the analysis provided P&L information for each of their plants. Many smaller beef packers were not included in the analyses because they did not have P&L data in electronic form. Although other smaller beef packers provided electronic data, they could not be included in the analysis for a variety of reasons. These reasons included incomplete data (e.g., missing fields), changes in accounting systems during the data collection period resulting in changes in the format of data reported, and extremely small volumes relative to the industry as a whole. Twenty-one plants owned by four beef packing companies reported data suitable for this analysis.

P&L data are maintained differently across the major packers. The structure of the P&L statements is different across firms, and there are large variations in the categories of information that are detailed. For example, some firms reported very detailed by-product revenue information, while other firms reported very few lines associated with revenue categories. The placement of specific types of information within P&L statements also varies across packers. Some firms reported labor as a variable cost, while others reported labor with other costs that are most likely fixed costs. Likewise, some firms reported plant costs as a fixed cost, and some reported plant costs with other costs that are most likely variable costs. Some of the largest firms reported slaughter and fabrication on separate P&L statements, even when the slaughter and fabrication operations were at the same facility site. The other firms combined slaughter and fabrication into a single P&L statement.

While all beef packing firms complied with the request for P&L data, analysis was only attempted for those with data in electronic form. In most cases, the electronic form of the P&L data were exact images of P&L statements. The level of detail provided in P&L statements varied by company. As mentioned above, they also differed in how they categorized variable and fixed costs. Thus, only data from plants that provided cost and revenue data in an electronic format and in sufficient detail were used in the analysis.

Because of the differences in P&L statements across firms, only basic information can be compared with confidence. Thus, the details reported in this section focus only on average total costs per head (ATC). Information is also provided on average gross margin per head (AGM) and average profit per head (PPH) but only for completeness.

Total costs, total gross margin, and total profits are available for each plant from each monthly P&L statement.[1] We divided each total by the number of head slaughtered or processed each month to create an average value per head per month figure. We constructed these variables for each plant within each firm included in the analysis.

Methodology for Analyzing Profit and Loss Data

This section describes the methodology used to analyze the beef packer P&L data. Because of the differences in P&L statements across firms, the analysis focuses on average total costs per head and not cost details. We conducted more detailed analysis of the firms that provided more detailed data and found the results to be generally consistent with those in this report. However, specifics of the disaggregated firm analyses will not be presented in order to preserve

[1] For plants that maintain P&L statements on a weekly basis, we aggregated the data to a monthly basis.

confidentiality and because comparisons across firms may be misleading. Fixed costs associated with plants could be easily identified for some packers and were of expected magnitudes. However, efforts to identify fixed costs for other packers resulted in magnitudes that were not reasonable.

Below, we describe the details of the models for ATC. We present the results in following section. Models are estimated for each plant. However, the results are aggregated over all plants to protect confidentiality. The aggregate plant can be thought of as a "representative" plant for the industry.

Total Costs per Head Model

The primary modeling effort using P&L data involves regressing ATC as a function of the volume processed or slaughtered and the percentages of volumes that are procured through AMAs. The basic ATC model is as follows:

$$\begin{aligned} TotalCostsPerHead_t &= \beta_0 + \beta_1 \ln(Volume_t) + \beta_2 (P\_FC_t) + \\ & \beta_3 (P\_MA_t) + \beta_4 (P\_PO_t) + \sum_j \alpha_j \, x_{jt} + \varepsilon_t \ , \end{aligned} \tag{1}$$

where *t* denotes the month within the sample. The variables *P_FC*, *P_MA*, and *P_PO* denote forward contract, marketing agreement, and packer-owned fed cattle, respectively, expressed as a percentage of total monthly procurement volumes. The term x_j represents other variables considered. For this application a trend variable was included a=and labor, energy, and capital input price variables obtained from the U.S. Bureau of Labor statistics sources. However, none of the input price variables were significant and of the correct sign and, thus, were removed from the final specification.

Separate models were estimated for each plant within each company. The semilogarithm form of the model specified above was found to be most appropriate for the majority of the plants. Thus, we used the semilogarithm form in all cases for uniformity across the firms and plants and for simplicity in programming the policy simulations. Quadratic ATC functions were not used for equation (1) because the data showed no points where ATC increased with higher volumes. Increasing ATCs with larger volumes was not observed in the data.

Coefficients on the AMA variables in equation (1) measure whether higher volumes of fed cattle purchased through AMAs are associated with lower ATC, as expressed on monthly plant-level P&L statements. In other words, the coefficients are direct-effect measurements of the cost differences caused by the use of AMAs for procuring cattle. Furthermore, these coefficients represent the cost differences that the firms see or recognize through their P&L accounting.

The model can be used to calculate or simulate changes in ATCs when AMA volumes are changed or limited because of policy intervention. For example, if a hypothetical restriction required that no cattle be procured through AMAs, then substituting zero for the AMA variables enables a calculation of the change in ATCs due to the restriction, while holding all else constant. Likewise, the effects of other types of restrictions can be simulated by varying the values substituted into equation (1). However, resulting estimates are specific to the sample of 30 months covered by the data collection (October 2002 through March 2005).

When using the model to conduct policy simulations, in addition to the direct effects, there are two important indirect effects that result. First, if a policy change results in reduced volumes of cattle slaughtered and processed at packing plants, then the effect of those changes can be measured through the volume coefficient in the ATC model. Thus, the cost impact of the volume reduction needs to be measured. Second, if a policy change results in changes in the variability in the number of cattle slaughtered and processed through packing plants, then the change needs to be measured. Random draws from the new distribution of cattle can be used with the ATC equation to measure the changes in average total costs due to a more variable supply of cattle for slaughter. The slope and curvature of the ATC function and increasing variability of procurement will result in increased costs.

Model of Plant-Level Volumes

Determining the changes in plant-level volumes and changes in variability brought about by changes in AMA volumes requires two additional modeling efforts. Changes in volumes are modeled as follows:

$$\begin{aligned} Volume_t &= \beta_0 + \beta_1(USDAFI_t) + \beta_2(FC_t) + \\ &\beta_3(MA_t) + \beta_4(PO_t) + \varepsilon_t , \end{aligned} \tag{2}$$

where the total volume of head slaughtered and processed at a plant (*Volume*) is modeled as a function of AMA volumes (*FC*, *MA*, and *PO*) measured in number of head and the monthly USDA federally inspected steer and heifer slaughter volumes (*USDAFI*) measured in thousands of head. We estimated one model for each plant so that plant-specific associations are measured. The *USDAFI* variable captures general changes in supply numbers. During the study period, cattle numbers were initially large because the market was in the liquidation phase of the cattle cycle. Cattle numbers were smaller toward the end of the sample, as the cycle changed to the expansion phase. In addition to the cattle cycle effects, a distinct seasonal pattern was also observed in the *USDAFI* variable. The model measures how changes in the total volume of cattle slaughtered and processed at a plant vary with changes in AMA volumes, while holding the total volume of cattle in the marketplace constant. Some plants readily substitute cash market cattle for AMA-procured cattle. For example, if volume of marketing agreement cattle decreases by 1,000 head, then those cattle might be offset by an increase of 900 cash market cattle and the total cattle purchase volume will decrease by 100 head. On the other hand, some plants substitute fewer cash market cattle to make up for variations in volumes of cattle procured through AMAs. For example, if the volume of AMA cattle decreases 1,000 head, then those cattle might be offset by 200 cash market cattle and the total volume will decrease by 800 head. Substantial differences occur across plants, and some plants appear to readily substitute across types of AMAs while other plants do not. However, this substitution holds constant the variations in total U.S. fed steer and heifer slaughter volumes.

As with the ATC model in equation (1), the volume model in Equation (2) can be used to simulate changes in individual plant volumes when AMA volumes are changed or limited because of policy intervention. If a hypothetical restriction required that no cattle be procured through AMAs, then substituting zero for the AMA variables would enable a calculation of the change in plant slaughter volumes due to the restriction, while holding all else constant. Likewise, the effects of other types of restrictions can be simulated by varying the values substituted into equation (2).

Model of Plant Volume Variability

The second modeling effort measures indirect effects on costs due to variability of plant-level cattle volumes obtained from different fed cattle procurement sources. By definition, the variance of plant volumes is the variance of the sum of the different procurement sources, as follows:

$$\begin{aligned} Var(Volume) &= Var(Cash + FC + MA + PO) \\ &= Var(X_1 + X_2 + X_3 + X_4). \end{aligned} \tag{3}$$

A constant is multiplied by each procurement source to maintain the mean level of total volume, as follows:

$$\begin{aligned} Var(Volume) &= Var(k_1X_1 + k_2X_2 + k_3X_3 + k_4X_4) = \\ &\sum_{i=1}^{4} k_i^2 Var(X_i) + \sum_{i=1}^{4}\sum_{j=1}^{4} k_i k_j Cov(X_i, X_j). \end{aligned} \tag{4}$$

For example, if half of the volume for a plant is procured from AMA sources, and if policy intervention prohibits the use of AMAs, then to maintain the mean total volume the plant will have to procure twice the volume from the cash market. The cash procurement constant is adjusted so that reductions in cattle through AMAs are added to the constant, ensuring the mean of total volume is preserved. Because of this adjustment, the variance changes are mean preserving. This method allows for estimation of a variability effect caused by changing use of AMAs, but changes in the variability of plant volumes are not confounded by changes in the mean of plant volumes.

The variance calculation can be used to simulate changes in variability of plant volumes when AMA volumes are limited because of policy intervention. If a hypothetical policy intervention requires that no cattle be procured through AMAs, then zeroing out the variables that represent AMA volumes will allow for calculation of the change in plant-level volume variability due to the policy change. These changes in variance are used in the simulation scenarios for the variance parameter presented in the simulation section.

Model Estimation Details

The ATC equations are estimated jointly for all plants within a firm using seemingly unrelated regression (SUR). The block of equations also contains other equations specific to each packer. For example, labor costs, plant costs, sales costs, boxed beef revenue, cattle costs, and other costs and revenues were available from some of the firm P&L statements. Models explaining the relationships among these variables were estimated along with the ATC models. Cost-related items were estimated with the same specification as the ATC model, and revenue-related items were estimated with the additional variable of the USDA Farm-to-Wholesale price spread. The limiting feature is that SUR cannot be estimated for cases in which a linear combination of some of the dependent variables equals another dependent variable. In these cases, equations were dropped from the system to allow estimation. However, we also examined the results of OLS estimation of these dropped equations. There is strong cross-equation correlation in the system of estimated equations. The errors for all of the ATC models across plants are highly correlated. Specifically, there are strong positive correlations between the errors for the ATC models. The SUR method appears to improve the model estimates, while also improving model efficiency.

Results of Profit and Loss Data Analysis

In this section, we begin with a description of the summary statistics of the data used in the modeling efforts and then we present results of the models described in next section. We also present the estimated effects on costs of the simulation scenarios in modeling the economic effects of restricting AMAs. Finally, we describe the implications of the results for determining whether efficiencies occur through use of AMAs.

Descriptive Statistics from the P&L Data

Summary statistics for ATC, AGM, and PPH are reported in Table 1. Values shown in Table 1 are weighted averages across plants, using the relative proportion of head slaughtered as the weights. As indicated in the table, the weighted average values for the time period of the data are as follows:

- ATC is $138.61 per head.
- AGM is $140.73 per head.
- PPH is a loss of −$2.40 per head.

ATC and AGM are typical values for costs and revenues. ATC does not include cattle costs, and AGM is revenue from beef and by-product sales net of cattle costs. The average PPH value is negative because some firms included irregular costs and revenues in their P&L statements. In addition, it was an unprofitable time for some beef packers because of tight cattle supplies. However, many individual plants or firms were profitable during most of the sample period, and some firms were more profitable than others. No one firm had all plants operating at an average positive profit for the entire period. However, the cost and profit variation within each firm was typically larger than across firms. High-cost firms are also high-gross margin firms, indicating either that additional processing creates additional value or that there are accounting differences across firms. The most profitable firm was a low-cost firm and relatively low-gross margin firm.

The variables for the percentage of fed cattle purchased through AMAs were created for each plant within each firm using the transactions data that were collect from each packer for the LMMS. The P&L data are monthly. Thus, the different sources of cattle by cash and AMA methods were totaled for each month for each plant within each firm, using the transactions data. The total numbers of cattle procured by each type of marketing arrangement are very close to the total numbers of cattle slaughtered and processed, as reported on the P&L statements. The average discrepancy was less than 1%, and the largest discrepancy was less than 2%.

Summary statistics of the AMA percentage variables are also reported in Table 1. For the period represented in the data, the weighted average percentages of AMAs used are as follows:

- marketing agreements—29.5% of the fed cattle volume
- forward contracts—4.2% of the fed cattle volume
- packer owned—less than 5% of the fed cattle volume
- other method—0.2% of the fed cattle volume
- missing—less than 1% of the fed cattle volume

The remainder of the volume was through cash markets and predominantly direct-trade (approximately 60%). The percentage variables used in the models and reported in the tables range from zero to one. For example, a 10% increase is 0.10. Large variation in procurement methods occurs across firms and for different plants within firms. The modeling methods described in earlier measure and account for the differences across plants within firms.

Other variables were included in the ATC model, but most were found to be unimportant in explaining the variation in ATCs across firms. These other variables are denoted as x_j in equation (1). For example, labor, energy, and capital input price variables were obtained from U.S. Bureau of Labor Statistics sources and included in the preliminary models. None of these variables were significant and of the correct sign, so were removed them from the final model. However, we did include a trend variable in the final model. Based on the estimated coefficient on the trend variable, real average total costs increased for most plants and firms over the sample period. We also included interactions terms between the input price variables and the AMA variables, but none of these interaction terms were significant. All of the dollar variables were deflated to 2004 dollars. However, inflation was mild in the sample period and deflating had little effect on the results.

Results of Estimation of the Volume Models

Results of the volume models (equation 2) are reported in Table 2. We estimated these equations in levels and first differences using OLS. However, we did not find large differences in the results, and therefore, we present and discuss the results of estimation in levels. Almost all of the volumes are stationary. The first differenced model is used in simulations for those volumes that are nonstationary. The coefficients, standard errors, and model statistics presented in Table 2 are weighted averages across all plants in the sample. The weights are the volume of cattle slaughtered or processed at that plant. Thus, the results can be considered to reflect a representative plant in the industry.

Based on the estimation of equation 2, decreases in procurement of fed cattle through marketing agreements, forward contracts, and packer-owned sources result in a substitution into cattle purchased in the cash market. The coefficients and implied elasticities for forward contract and packer-owned cattle are small compared with marketing agreement cattle. The specific results are as follows:

- A 1% decline in forward contract cattle is estimated to result in a 0.0098% decline in the total volume of cattle purchased and a 0.9902% increase in the volume of cattle purchased in the cash market.
- A 1% decline in packer-owned cattle is estimated to result in a 0.0120% decline in the total volume of cattle purchased and a 0.9880% increase in the volume of cattle purchased in the cash market.
- A 1% decline in marketing agreement cattle is estimated to result in a 0.1744% decline in the total volume of cattle purchased and a 0.8256% increase in the volume of cattle purchased in the cash market.

Thus, based on these results, it appears that packers readily substitute cattle purchased on the cash market for cattle procured through forward contracts and packer ownership. Based on these results, and because the percentage of cattle that are forward contracted or packer owned is small, a policy that affects forward contracting or packer-owned procurement of fed cattle would have little effect on individual plants or the overall market. However, such a policy would have a large effect on some packers and some plants owned by specific packers. Unlike with forward contract and packer-owned cattle, packers do not appear to be able to readily substitute cash market cattle for marketing agreement cattle. Therefore, a policy that affects procurement of cattle through marketing agreements likely would result in packers operating plants at lower volumes. Cattle slaughter plants that currently procure a substantial portion of their cattle through marketing agreements would be particularly affected.

Based on results of estimation of equation (3), volumes of cattle procured through the cash market are typically almost twice as variable as the volumes of cattle procured through AMAs. Thus, elimination of AMAs would increase the variability of volumes slaughtered and processed at plants. Specifically, the weighted average variability of volumes at cattle slaughter plants is 174% greater when cattle are procured only through the cash market compared with when cattle are procured through both the cash market and AMAs. In other words, the mean-preserving variance change suggests that if packers are required to purchase all cattle in the cash market, the monthly slaughter and processing volumes would be 74% more variable than current slaughter and processing volumes. Because of the curvature of the ATC function, costs would also increase.

This general conclusion about the relative magnitude of the variability is supported by secondary data provided by USDA AMS' MPR, which began in 2001. MPR data provide information of the volume of transactions through the cash market and AMA sources. Since 2001, there have been fairly large changes in cash market volumes and AMA volumes. However, the variability of cash volumes, as measured by month-to-month changes, is clearly larger than for AMA volumes. Depending on the sampling interval, monthly cash market volume variability is two to four times larger than AMA volume variability.

Results of Average Total Cost Model Estimation

Results of the ATC (equation 1) model are presented in Table 3. The model coefficients, standard errors, and summary statistics are weighted averages across all of the plants; the weights are the total volume slaughtered and processed for each plant over the sample period.

Model efficiency is clearly improved between the OLS and SUR results. However, the SUR results are more uniform and more coefficients are significant across plants for the volume and percentage of AMA variables.

The primary result from the ATC model estimates shows that there are substantial economies of size for meat packing firms. Larger firms have substantially lower costs at higher slaughter volumes. The predicted values from the estimated equation fit through the center of the actual data in a each XY plot. In addition, the predicted values from the estimated equations do not miss the data at the edges of the data ranges. The volume variable in the ATC models accounts for 70% to 90% of the reported R^2. The results for a representative firm have an R^2 of 58%.

Based on the individual plant model results, when larger plants operate with smaller volumes, they have higher costs than smaller plants operating close to capacity. Thus, the importance of large plants operating at capacity is apparent. Likewise, small plants appear to have cost advantages relative to large plants when volumes are smaller. However, smaller plants are at an absolute cost disadvantage compared with larger plants when both are operated at close to capacity. The lowest cost for larger plants is typically $1 to $3 per head lower than the lowest cost for smaller plants.

However, for all plants, ATCs increase sharply as volumes are reduced. Figure 1 illustrates the ATC function for a representative plant over the representative range of plant slaughter volumes. A representative plant operating at 95% of the maximum observed volume is 6% more efficient than a plant operating in the middle of the observed range of volumes and is 14% more efficient than a plant operating at the low end of the observed range. The ATC function displays some curvature but the curvature is slight. We also observe this slight curvature in the raw data; ATCs decline sharply and continuously over the observed slaughter volumes. In addition, ATCs never appear to increase at higher volumes in the data, nor is there a flat spot reflecting the minimum of the function. This result is similar to much of the past research on meat packing economics and specifically to the results found by Ward (1990, 1993) and summarized in MacDonald (2003). However, the result remains striking. The magnitude of scale economies is substantial and clearly a main factor in the decision-making process of meat packing firms.

The effects of AMA volumes on ATC are somewhat mixed but primarily as hypothesized. In general, increases in the percentages of cattle procured through AMAs, while holding total volume constant, are associated with lower ATCs. AMAs appear to allow for predictable cattle procurement volumes and cattle quality and thus enable the packer to reduce slaughter and processing costs. However, for some plants, the percentages of cattle procured through AMAs appear to have no effect, and in other plants, higher percentages of cattle procured through AMAs are associated with higher total slaughter and processing costs. Approximately 49% of the coefficients on the AMA variables were negative, and 51% were positive. Negative signs were expected prior to estimation. Of the negative coefficients, 33% were statistically significant, and of the positive coefficients, 9% were statistically significant.

The weighted average results in Table 3 indicate that a 1% increase in the percentage of cattle procured through marketing agreements is associated with a $0.12 per head (0.1%) decrease in slaughter and processing costs, holding the total volume slaughtered and processed constant. This result appears to be statistically insignificant in Table 3, but the reported coefficient and standard error include all of the significant and insignificant results across all plants and firms. The plants with statistically significant coefficients in the ATC models have estimated coefficients in the –$0.12 to –$0.18 per head range, for a 1% change in procurement of fed cattle though marketing agreements. Based on examination of the individual firm-level equation estimates, some firms and some plants within those firms are able to reduce plant operating costs using AMAs, whereas some firms are not experiencing those same cost reductions.

While the percentage of cattle procured through marketing agreements has the largest significant effects on ATCs based on the individual firm-level estimates, the percentage of cattle procured through forward contracts also has a large effect, although many of the individual plant coefficients are insignificant. For a representative plant, a 1% increase in the percentage of cattle procured through forward contracts is associated with a $0.17 per head (0.1%) decrease in slaughter and processing costs, holding the total volume slaughtered and processed constant. However, the percentage of cattle procured through forward contracts is much smaller than that for marketing agreements, so the total effect of forward contract cattle on slaughter and processing costs is smaller. Most of the results for individual plants were insignificant, but some individual plants experienced reduced costs due to procurement of cattle through forward contracts.

Finally, the sign of the coefficient associated with the percentage of cattle procured through packer ownership is not as expected and the estimated coefficients are statistically insignificant. These results occur both for a representative plant and for individual plants. The results imply that a reduction in the percentage of cattle procured through packer ownership reduced ATCs. For a representative plant, a 1% increase in the percentage of cattle procured through packer ownership is associated with a $0.03 per head (<0.1%) increase in slaughter and processing costs, holding the total volume slaughtered and processed constant. The result is counterintuitive because, if packer-owned cattle result in higher costs, it is not clear why packers would own cattle. However, it may be that cattle are owned by the packer for reasons other than improving plant operations, and these reasons are not apparent on the P&L statements. Another explanation is that the results are due to the uniqueness of the time period and short time frame of the sample. Furthermore, very few firms own cattle and, for firms that do own cattle, they use these cattle to supply relatively few plants.

One of the unique characteristics of the period included in the analysis was the border closing for live imports of cattle and beef from Canada after the discovery of bovine spongiform encephalopathy (BSE) in Canada in May 2003. This closure caused major disruptions in the U.S. market. Then, in January 2004, many countries stopped allowing imports of beef from the U.S. because of the discovery of BSE at the end of December 2003. The time period between the closing of the border with Canada and the closing of the border to exports was a period of disrupted flow of cattle and beef. The prices of fed cattle in the U.S. increased above $1.00 per pound liveweight, which is a historical market precedent.

Based on our examination of this data, the packers that had packer-owned cattle appeared to have foreseen the shortage of fed cattle in fall 2003. They owned larger numbers of fed cattle than they typically do, and many of these fed cattle were slaughtered and processed in fall 2003. The costs of slaughtering and processing that appear in packer P&L statements during fall 2003 are larger than typical costs because of the reduced volumes slaughtered during that time. It is likely that some other factors affected costs associated with packer-owned cattle, but the regression model assigns the higher costs to slaughtering and processing of packer-owned cattle. It could be that packer-owned cattle are not higher cost cattle but that firms with packer-owned cattle experienced higher costs associated with disruption of the market. The firms and plants for which packer-owned cattle increased costs operate in regions that were more affected by the loss of Canadian fed cattle imports and beef products exports.

When considering the results of the ATC models, there are also issues within firms related to accounting practices and the usefulness of examining accounting data to understand economic behavior. For example, the ATCs for all plants within some firms were substantially lower than other firms within the same month. In addition, firms may have had substantially higher ATCs in one plant while simultaneously having substantially lower ATCs in other plant. It appears that firms are making decisions about the assignment of costs and revenues to plants within the firm. We included binary variables in the models to account for these differences across plants. However, there is some question as to whether subtle changes in costs can be observed with substantial confidence when the accounting data also contain "random" assignments of costs (from the econometrician's standpoint). Thus, there will be some sample-specific results and plant-specific results that cannot be explained.

Another general observation is that costs were higher and profits lower for some firms and some plants within firms during the market disruptions of 2003. These changes cannot be attributed solely to reduced volumes and the market condition variables included in the models. In other words, the unique market disruptions during the time period of the data appear to have caused higher costs within some firms.

Simulation Scenario Results

Results from the ATC models are used to calculate the estimated changes in costs associated with hypothetical restrictions on AMAs for the simulation model. The scenarios included in the analysis are (1) a 25% reduction in volumes of cattle procured through AMAs and (2) a 100% reduction in volumes (or elimination) of cattle procured through AMAs. We simulated the effects of these scenarios in the ATC models, which hold constant other variables included in the model, and incorporated the volume and variance calculations. The policy interventions suggested within each scenario are incorporated into the cost models. We then multiplied the estimated effects by the percentage of industry cattle slaughter volumes represented by the firms in the analysis. This adjustment assumes that the effects of the simulation scenarios do not generalize to the other smaller firms in the industry.

The estimated cost changes for each scenario are presented in Table 4. Three types of cost changes are presented. The first cost change is the direct cost change measured by the estimated coefficients on *P_FC*, *P_MA*, and *P_PO*. For example, in scenario 2 in which all AMAs are eliminated, the variables are replaced with zero, the absolute change in ATC for each plant is calculated, and then the absolute change in ATC is converted to a percentage basis.

The second cost change is that implied by the volume change. The volume models are used to calculate a change in plant volumes under each scenario. This estimated change in volume is then used in the ATC equation to calculate an absolute change in ATC, and then the absolute change in ATC is converted to a percentage basis. This change in costs due to change in volume does not include the direct change in ATC measurements; the two are embedded but the direct effect is netted out.

The third cost change is due to increased volume variability. First, we make a random draw from the distribution of volumes observed in the data. This distribution has a variance implied by the simulation scenario. Each random draw from the distribution of volumes is used in the ATC equation to calculate a predicted ATC value. Randomness in the ATC equation is added by including a random draw from the distribution of error terms from the ATC model. The number of replications (or random draws) used is 10,000. The change in costs due to changes in variability does not include the direct change in ATC measurements; the two are embedded but the direct effect is netted out. The change in variability also does not include a change in volume. The mean volume is preserved and only the variance is changed.

The distribution of cattle volumes slaughtered and processed for each plant is assumed to be a generalized beta distribution unique to that plant. The distribution of ATC model errors is a normal distribution based on statistical tests, but the plant volumes are not. If a normal distribution was used to simulate changes in plant volumes, the random draws at the top end of the distribution would be much larger than any volumes observed in the data. However, each plant has an installed capacity above which the plant cannot process. Using a generalized beta distribution addresses this problem. The maximum parameter is chosen to be 5% more than the observed maximum and the minimum parameter is chosen to be zero. The other two parameters in the beta distribution, α and β, are estimated through maximum likelihood. The variance is then increased by the prescribed amount by changing the parameter values. In all cases, the distribution is broader, with more mass in the top end of the distribution (but not equal to or over the maximum of the range) and with more mass in the lower end of the distribution over the center of the volume range. Example beta distributions are shown in Figure 2. One distribution uses parameters similar to actual plants (i.e., the “before” line), and the second shows the change in the distribution shape resulting from increasing the variance by 90% (i.e., the “after” line).

In the simulation, the percentage AMA variables are used to calculate the direct effects in each simulation scenario if the coefficient estimates are significant at the 10% level.[2] The estimated effects of a 25% reduction in AMA use (scenario 1) are as follows:

- a total increase in ATC of 0.86% resulting from
  - a 0.22% direct increase in ATC,

[2] In some cases, coefficients that were significant at the 11% or 12% level were used if the magnitudes were reasonable.

  - a 0.49% increase in ATC due to reduced volumes, and
  - a 0.15% increase in ATC due to increased variability in slaughter and processing volumes
- a decrease in cattle procurement volume of 1.96%
- an increase in cattle procurement variability of 10.90%

The estimated effects of a 100% reduction in AMA use (scenario 2) are as follows:

- a total increase in ATC of 4.68% resulting from
  - a 0.88% direct increase in ATC,
  - a 2.57% increase in ATC due to reduced volumes, and
  - a 1.23% increase in ATC due to increased variability in slaughter and processing volumes
- a decrease in cattle procurement volume of 8.04%
- an increase in cattle procurement variability of 73.90%

Summary

In conclusion, this analysis of P&L data from beef packers is the first of its kind. The data provided an opportunity to examine packer plant–level P&L data for evidence of economies of size and cost economies related to procurement of cattle through different types of AMAs.

The research results clearly document economies of size in beef packing. Average total cost functions are downward sloping over the entire range of volumes slaughtered and processed. In addition, there appears to be substantial cost savings to firms and to the market when plants operate at capacity and substantial diseconomies and losses when plants do not. The excess capacity currently present in the industry is an economic problem because, from a cost and efficiency standpoint, the excess investment in plant capacity is an economic loss.

Based on the results presented in this section, procurement of cattle through AMAs results in cost savings to the firms that use them. However, the results differ across firms. Some firms benefit substantially from AMAs and other firms do not appear to capture any benefits. We draw these conclusions from beef packing firms' own accounting data. The direct cost savings from AMAs is approximately 0.9% of ATCs, or approximately $1.22 per head. Packers also experience additional cost savings from reduced variability in cattle supplies ($1.70 per head) and increased slaughter volumes ($3.56 per head) at packing plants. The total cost savings associated with AMAs is approximately $6.50 per animal. For an industry with an average loss of $2.40 per head during the 30-month sample, this is a substantial benefit.

Thus, the results indicate clear evidence that procurement of cattle through AMAs results in reduced costs and increased profitability for the firms that use them, although it is important to keep in mind that the results differ across firms. While some firms appear to be reducing costs through some means by procuring cattle through AMAs, others do not.

It is also important to keep in mind that within the beef industry, AMAs are largely marketing agreements. Forward contracts and packer ownership are used, but to a lesser extent. Thus, restrictions on the use of marketing agreements would have the greatest negative effects on the beef industry. Restrictions on the use of packer ownership and forward contracts for cattle would have lesser effects.

Table 1: Weighted Average Summary Statistics for Variables Used in the Average Total Cost per Head, Average Gross Margin per Head, Average Profit per Head, and Volume Equations.

Variable	Mean	Standard Deviation	Minimum	Maximum
Average total cost per head (ATC)	\$138.61	10.7476	120.3196	164.2098
Average gross margin per head (AGM)	\$140.72	38.8241	22.6245	211.9827
Average profit per head (PPH)	–\$2.40	43.8242	–137.3646	73.3409
AMA volumes (%)				
Forward contract	0.0424	0.0414	0.0020	0.1661
Marketing agreement	0.2951	0.0742	0.1716	0.4594
Packer owned	D[a]	D	D	D
Other	0.0016	0.0024	0.0000	0.0092
AMA volumes (no. of head)				
Forward contract	18,216	4,086	196	16,884
Marketing agreement	145,227	9,398	14,121	52,121
Packer owned	D	D	D	D
Other	1,340	250	0	1,004
Total fed cattle volume (no. of head)	426,759	14,341	68,102	127,845

D = Results suppressed.

[a] This variable has an upper bound of 0.05.

Table 2: Weighted Average Results of the Models of Total Plant Volumes, as a Function of AMA Volumes.

	Plant Volume Levels Coefficient (Standard Error)	Implied Elasticities	Plant Volume Changes Coefficient (Standard Error)
Mean dependent variable	103733	—	–574.1694
Standard deviation of error	8558.2429	—	9186.7250
Intercept	90261.7364	—	–339.5124
	(6950.7315)		(1718.4385)
Quantity of forward contract cattle	0.2289	+0.0098	0.1140
	(0.5226)		(0.4742)
Quantity of marketing agreement cattle	0.5125	+0.1744	0.3827
	(0.3154)		(0.3434)
Quantity of packer-owned cattle	0.0394	+0.0012	0.0507
	(0.0957)		(0.1006)
R^2	0.6561	—	0.5527

Note: All results are weighted average values across plants.

Table 3: Weighted Average Results of the Average Total Cost per Head, Average Gross Margin per Head, and Average Profit per Head Equations.

	Average Total Cost
Mean dependent variable	138.6078
Standard deviation of error	7.4986
Intercept	497.0765
	(88.53819)
Ln (Volume)	–31.2401
	(7.6893)
Percentage of forward contract cattle	–16.5507
	(30.5976)
Percentage of marketing agreement cattle	–12.1548
	(20.2700)
Percentage of packer-owned cattle	3.3190
	(7.4724)
R^2	0.5763

Note: All results are weighted average values across plants.

Table 4: Simulated Effects of Restricting Fed Cattle AMA Volumes on Monthly Average Total Costs per Head, Average Gross Margins per Head, and Average Profit per Head.

Effect	25% Reduction in AMA Volumes	100% Reduction in AMA Volumes
Percentage change in average total cost		
Direct measurement	+0.0022	+0.0088
Change due to reduced volumes	+0.0049	+0.0257
Change due to increased variability	+0.0015	+0.0123
Total percentage change in average total cost	+0.0086	+0.0468
Percentage change in total volume	–0.0196	–0.0804
Percentage change in variability	+0.1090	+0.7390

Figure 1: Average Total Cost per Head Curve for a Representative Fed Cattle Slaughter Plant.

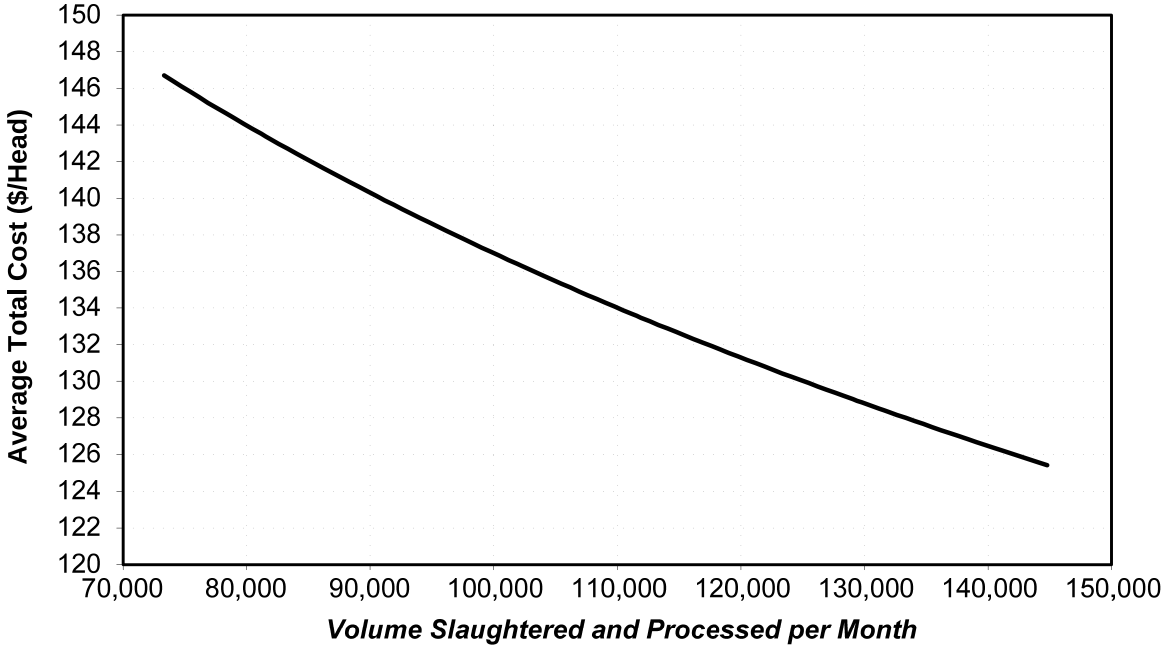
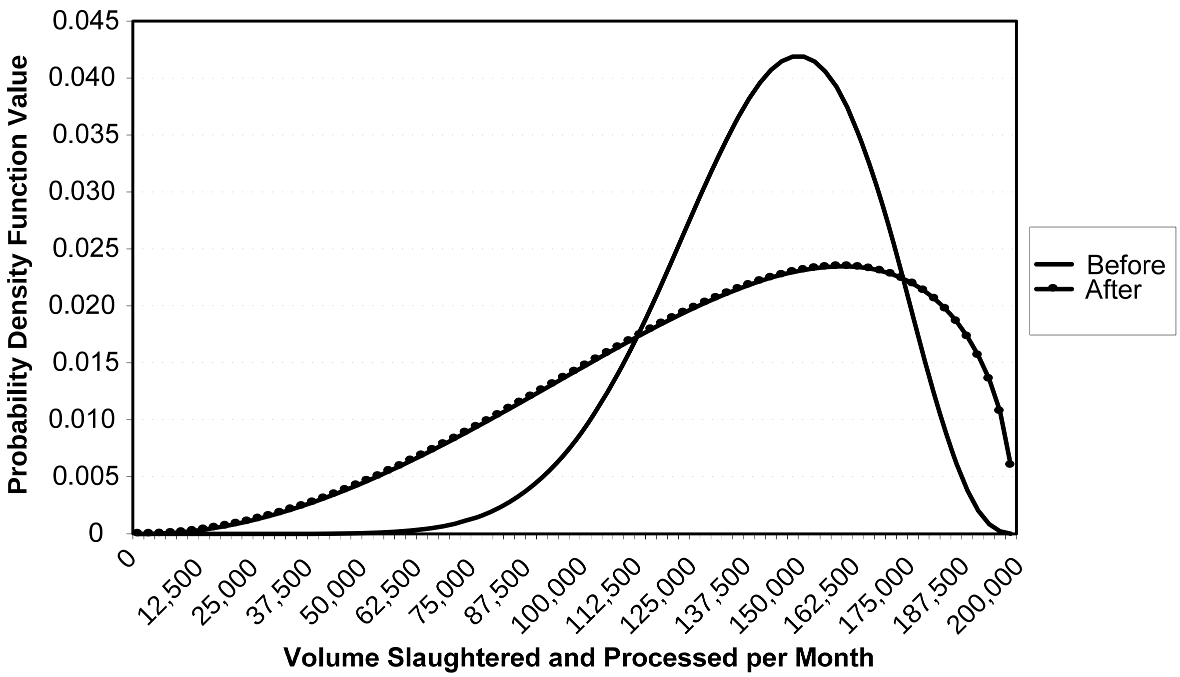


Figure 2: Example Beta Distribution for Fed Cattle Procurement Volumes Before and After a 90% Increase in Procurement Variance (Mean Value is Held Constant).



References

Azzam A.M. “Captive Supplies, Market Conduct, and the Open-Market Price.” *American Journal of Agricultural Economics* 80(1998):76-83.

Elam, E. “Cash Forward Contracting vs. Hedging of Fed Cattle, and the Impact of Cash Contracting on Cash Prices.” *Journal of Agricultural and Resource Economics* 17(1992):205-217.

Feuz, D., G. Grimes, M.L. Hayenga, S.R. Koontz, J.D. Lawrence, W.D. Purcell, T.C. Schroeder, C.E. Ward. “Comments on Economic Impacts of Proposed Legislation to Prohibit Beef and Pork Packer Ownership, Feeding, or Control of Livestock.” White Paper, Research Institute on Livestock Pricing, Virginia Tech, Blacksburg, VA, 2002.

French, B.C. “The Analysis of Productive Efficiency in Agricultural Marketing: Models, Methods, and Progress.” L.R. Martin, Ed., *A Survey of Agricultural Economics Literature*, University of Minnesota Press, 1977.

MacDonald, J.M. “Beef and Pork Packing Industries.” *The Veterinary Clinics: Food Animal Practice* 19(2003):419-443.

Purcell, W.D. *Agricultural Marketing: Systems Coordination, Cash and Futures Markets*. Reston, VA: Prentice-Hall, 1979.

Schroeder, T.C., R. Jones, J. Mintert, and A.P. Barkley. “The Impact of Forward Contracting on Fed Cattle Transactions Prices.” *Review of Agricultural Economics* 15(1993):325-337.

Schroeter, J., and A. Azzam. “Econometric Analysis of Fed Cattle Procurement in the Texas Panhandle.” Report prepared for USDA, GIPSA, Washington, DC, 1999.

Schroeter, J.R. and A. Azzam. “Captive Supplies and the Spot Market Price of Fed Cattle: The Plant-Level Relationship.” *Agribusiness: An International Journal* 19(2003):489-504.

Ward, C.E. “Meatpacking Plant Capacity and Utilization: Implications for Competition and Pricing.” *Agribusiness: An International Journal* 6(1990):65-73.

Ward, C.E. “Comparative Analysis of Cattle Slaughtering and Fabrication Costs.” *Agribusiness: An International Journal* 9(1993):441-451.

Ward, C.E., S.R. Koontz, and T.C. Schroeder. “Impacts from Captive Supplies on Fed Cattle Transactions Prices.” *Journal of Agricultural and Resource Economics*. 23(1998):494-514.

Wohlgenant, M.K. “Demand for Farm Output is a Complete System of Demand Functions.” *American Journal of Agricultural Economics* 71(1989): 241-252.