Evidence of the Role of Marketing Arrangements and Valuation Methods in Improving Beef Quality

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ABSTRACT

Low and inconsistent beef quality has been blamed by some for the losses of beef's share of total meat consumption. Tighter vertical coordination through use of alternative marketing arrangements and more precise price signaling through use of different cattle valuation methods may help improve beef quality because these mechanisms facilitate information exchange enabling producers to respond better to consumer demand. For the congressionally mandated Livestock and Meat Marketing Study, we modeled differences in levels and variances of cattle quality associated with particular marketing arrangements and valuation methods using fed cattle purchase data from 29 large U.S. beef packing plants for October 2002 through March 2005. Results indicate fed cattle procured through marketing agreements and packer ownership had higher and more consistent quality compared to other types of arrangements. Auction market cattle quality was the most inconsistent. Fed cattle valued using carcass weight with a grid were associated with higher and more consistent quality. [EconLit Citation: Q13].

1. INTRODUCTION

Low and inconsistent beef quality has been blamed by some for the losses of beef's share of total meat consumption over the period 1950 through 1996 (Purcell, 1989; Schroeder, Ward, Mintert, & Peel, 1998). Improvements in beef quality, to a large extent, depend on how effectively consumer preference can be conveyed to producers through the supply chain in the beef industry. Tighter vertical coordination and more precise price signals may help improve beef quality because they facilitate information exchange, thus enabling producers to respond better to consumer demand. The beef industry has exhibited both tighter vertical coordination and more precise price signaling between cattle producers and beef packers in recent years. Specifically, more cattle were procured using alternative marketing arrangements (AMAs) instead of traditional cash or spot market arrangements. Alternative marketing arrangements, such as forward contracts, marketing agreements, and packer ownership, are characterized by closer vertical coordination between cattle producers and beef packers. In addition, more cattle were priced using carcass weight basis with a grid

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instead of traditional liveweight basis valuation. Use of a grid means that producers receive premiums and discounts for specific quality characteristics such as U.S. Department of Agriculture (USDA) Quality Grade, USDA Yield Grade, and carcass weight. By assigning premiums to higher quality cattle and discounts to lower quality cattle, carcass weight with grid valuation provides incentives for producers to produce better-quality cattle aligned with consumer demand.

Many authors have discussed the significance of tighter vertical coordination in quality control (Anton, 2002; Raper, Black, Hogberg, & Hilker, 2005; Schroeder, Jones, Mintert, & Barkley, 1991; Ward, 2003; Ward & Bliss, 1989; Whitley, 2002). Beef industry surveys also suggest that the ability to obtain higher and more consistent beef quality is an important incentive for packers to move toward closer vertical coordination (Muth et al., 2007). However, there is little empirical work that directly tests this relationship.[1] Similarly, the relationship between beef quality and value-based pricing methods has also been widely discussed (Feuz, 1999; Schroeder & Graff, 2000; Schroeder et al., 1998; Whitley, 2002), but empirical work testing this relationship is scant. Taking advantage of a unique transaction data set collected under the Grain Inspection, Packers and Stockyard Administration (GIPSA) Livestock and Meat Marketing Study, we aim to empirically test (a) whether higher and more consistent beef quality is systematically related to closer vertical coordination through AMAs, and (b) whether higher and more consistent beef quality is systematically related to more precise price signals.

Use of AMAs is a contentious issue for some cattle industry members and, as a result, policy makers have introduced a number of Congressional bills to limit their use. The most well known of these bills was the Johnson Amendment to the 2002 Farm Bill, which would have prohibited the use of AMAs (or captive supplies). As a compromise to the proposed legislation, Congress mandated and funded the GIPSA Livestock and Meat Marketing Study to understand the full range of costs and benefits associated with use of AMAs. A limitation of prior related research on the use of AMAs is that they focused primarily on the costs or market power associated with AMAs (e.g., Azzam, 1998; Elam, 1992; Schroeder, Jones, Mintert, & Barkley, 1993; Schroeter & Azzam, 1999, 2003; Ward, Koontz, & Schroeder, 1998). In contrast, the research presented in this article examines the benefits of use of AMAs as they relate to quality of cattle and beef products.

One justification for the use of AMAs is that they allow packers to secure supplies of cattle that are of better and more consistent quality. Use of AMAs involves business relationship investments by both the buyer and seller and may permit improved coordination. Alternative marketing arrangements may also reward investment in product development and provide predictable raw material supplies. Lastly, AMAs may reward sorting within the cattle population to target particular animals to the correct market outlet.

The approach used in this article measures the level of quality and the unpredictable variability or inconsistency associated with AMAs and cash market arrangements. Previous research has not measured differences in quality, but has hypothesized that improved coordination helps improve quality. Restrictions on use

[1]Whitley (2002) found that a higher fraction of cattle marketed through the nonspot market is systematically related to higher average beef quality, using weekly market-level aggregated data. However, this is not a direct test of the relationship between beef quality and use of specific market channels.

of AMAs will not change the overall quality or consistency of beef products if cattle are simply sorted into different marketing and valuation methods. However, restrictions on use of AMAs will reduce overall quality and consistency of beef products if they cause producers to change production practices that enhance quality. In this latter case, restrictions on use of AMAs would have negative effects on economic welfare.

The remainder of this article is organized as follows. In the next section, we discuss types of quality measures, marketing arrangements, and valuation methods in the beef industry. We then describe transaction data used for the analysis, present three empirical models, and discuss the estimation results. Finally, we provide a summary and conclusions.

2. QUALITY MEASURES, MARKETING ARRANGEMENTS, AND VALUATION METHODS USED IN THE BEEF INDUSTRY

Carcasses are inspected for wholesomeness by the USDA's Food Safety and Inspection Service (FSIS) or by a state government inspection system and may be graded for quality by USDA's Agricultural Marketing Service (AMS). Federal inspection by FSIS is currently required for interstate shipment of meat. Grading for quality grade is not required, but fed cattle are almost always graded because quality grades are used as the primary measure of quality in the beef industry. Quality grade refers primarily to carcass maturity and amount of intramuscular fat with the grades designated as Prime, Choice, Select, and Standard. Cattle that are expected to grade Standard are typically not graded and are referred to as "No-Roll." Connective tissue in meat is more substantial in older animals, and meat flavor may be stronger and "gamier." Intramuscular fat, the fat tissues that are within the muscle as opposed to fat layers between muscles, impart mild flavors and hold moisture in cooking. Thus, intramuscular fat is desirable and results in a higher quality grade. Yield grade is the amount of meat or salable meat in the carcass and is designated as Yield Grades 1 through 5. Increases in the amount of fat cover between the hide and carcass and fat deposits close to edible organs and smaller muscles result in a lower yield grade (i.e., Yield Grade 4 or 5). Although yield grades are important to packers because they affect the amount of labor required to prepare beef cuts from a carcass, they are not relevant as a measure of quality for consumers.

The primary types of marketing arrangements used for sales of fed cattle to packers can be segregated into cash and AMAs. Cash marketing arrangements include

- Auction barn sales, including video and electronic auction sales.
- Use of dealers and brokers (individual negotiations between buyers and sellers).
- Direct trade (individual negotiation between buyers and sellers).

In contrast, AMAs include

- Forward contracts for the future purchase of a specified quantity of cattle 2 or more weeks in the future.
- Marketing agreements for the future purchase of cattle under a long-term ongoing arrangement.

- Packer ownership in which the packer owns the cattle 2 or more weeks prior to slaughter.

In addition to these key types of arrangements, a small number of cattle are custom slaughtered with the cattle producer maintaining ownership of the animal through the slaughter process and marketing the resulting beef products (Muth et al., 2007). Alternatively, a beef marketing company might contract with fed cattle producers to purchase cattle, contract with a packer to custom slaughter the cattle, and then market and distribute the resulting beef products.

All fed cattle sold through auctions are sold using liveweight valuation, but other types of marketing arrangements could use any of the three main types of valuation methods (liveweight, carcass weight with a grid, and carcass weight without a grid). Liveweight valuation means prices are paid based on the number of pounds the live animal weighs. Carcass weight valuation means prices are paid based on the number of pounds the carcass weighs. If a grid is used in combination with carcass weight valuation, prices are adjusted by premiums and discounts based on the weight range, quality grade, and yield grade of the carcass. Thus, of the three main types of valuation methods, carcass weight with a grid valuation is the only method that provides signals back to cattle producers that align with consumer demand for quality.

In the industry surveys conducted for the Livestock and Meat Marketing Study, we asked fed cattle producers and beef packers the three most important reasons for using either cash markets or AMAs (Cates et al., 2007). Many of these reasons relate to ensuring quality of cattle and beef products. In the fed cattle producer survey, 16.3% of respondents who use only the cash or spot market report doing so because it allows for the sale of higher quality calves and cattle, presumably at higher prices to reflect the higher quality. In contrast, 51.6% of cattle producer respondents who use an AMA report do so because it allows for the sale of higher quality calves and cattle. Most cattle producer respondents use only the cash market. However, they ranked seven other reasons for using these types of arrangements higher than quality. In contrast, for the relatively fewer cattle producer respondents that use AMAs, quality was ranked highest.

In the beef packer survey, 44.3% of respondents that use only the cash market report doing so because it allows for the procurement of higher quality fed cattle. In contrast, 53.8% of beef packer respondents that use AMAs, all of which are among the largest packing plants, report doing so because it secures higher quality fed cattle. Interestingly, this reason was ranked second among the list of possible reasons for both groups of respondents, thus indicating that packers are making the best choices regarding choice of marketing methods based on their own individual circumstances and business opportunities. However, beef packer respondents that use AMAs also indicated that AMAs allow for product branding in retail sales (46.2%) and improve efficiency of operations due to animal uniformity (42.3%); both of these characteristics are indications of better quality cattle.

3. FED CATTLE TRANSACTION DATA

The data used for the analyses represent all fed cattle purchase transactions for 29 of the largest beef packing plants in the United States over the October 2002 through March 2005 period. These 29 plants are owned by 10 individual companies with most

but not all companies owning multiple plants. The data were collected by RTI International (Research Triangle Park, NC) under contract with GIPSA in spring 2006. Because of the confidential nature of the data, the data were collected and maintained under the provisions of the Confidential Information Protection and Statistical Efficiency Act (CIPSEA) of 2002.[2] Data collected under CIPSEA can be used only for statistical analysis purposes and cannot be used for investigations. Furthermore, results of analyses cannot reveal plant- or company-specific information.

The data set used for the analysis includes 572,000 lots of beef and dairy breed fed cattle averaging approximately 100 cattle per lot. The data set includes transactions from 5 plants in the Cornbelt/Northeast (IA, IL, MI, MN, PA, and WI), 17 plants in the High Plains region (CO, KS, NE, and TX), and 7 plants in the West (AZ, CA, ID, UT, and WA). The volume of cattle in the data set represents approximately 85% of the fed cattle slaughtered in the United States during the October 2002 through March 2005 period based on USDA federally inspected fed steer and heifer slaughter data (USDA/NASS, various years).

The data represent an interesting period in the fed cattle industry because of the disruptions in the market that occurred first in May 2003, when the first discovery of bovine spongiform encephalitis (BSE) was made in Canada and the border was closed to live cattle and beef imports into the United States, and then in December 2003, when the first discovery of BSE was made in the United States and exports of beef from the United States were banned and some consumers decreased their consumption of beef. Thus, considerable variation occurs in the baseline market conditions within this data set, including periods of relatively low and relatively high cattle supplies.

The variables in the data set include location of the plant, transaction dates, seller information, number of cattle in the lot, costs of the lot, weight measures (e.g., liveweight and carcass weight), characteristics of the cattle sold (quality grade, yield grade, and other quality measures), and characteristics of the marketing arrangement used. Fed cattle purchase lots typically range from 10 to 200 cattle per lot.[3] Within an individual lot, the quality and characteristics of cattle may vary substantially depending on breed, distribution of steers versus heifers, whether any cattle are culled cows or bulls, weight range, quality grade, and yield grade.[4]

Table 1 shows the percentages of cattle by quality grade, yield grade, branding or certification, and weight range by type of marketing arrangement. Overall, 35% of fed cattle were graded Prime or Choice. Fed cattle sold through auction barns and dealers/brokers had the highest percentage of Prime and Choice quality grades, while fed cattle transferred under packer ownership had the lowest percentage. The percentages of Prime and Choice cattle for direct trade, forward contracts, and marketing agreements were relatively more similar. Most fed cattle were Yield Grade 2 and 3 across all types of marketing arrangements. The highest percentages of fed cattle that were branded or certified were for packer

[2]The text of the public law can be found at http://www.eia.doe.gov/oss/CIPSEA.pdf.

[3]Smaller lots of cattle are typically off-quality cattle that are not quality graded.

[4]Other quality indicators are used increasingly for fed cattle (e.g., organic, natural, and age verified). However, these measures are not captured in the transaction data and thus were not addressed in this analysis.

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TABLE 1. Fed Cattle Quality Measures Based on Transaction Data, by Fed Cattle Procurement Method, October 2002–March 2005 (Percentage of Head)

Quality measure	Auction barns	Dealers or brokers	Direct trade	Forward contract	Marketing agreement	Packer Fed/Owned	Other or missing	Total
Quality grade								
Prime	6.0	9.0	2.3	2.7	1.8	1.1	3.5	2.3
Choice	53.8	69.7	31.9	32.0	34.6	10.6	46.1	33.0
Upper choice	D	0.0	10.5	10.4	13.6	D	D	10.8
Lower choice	D	0.0	15.3	16.4	13.1	D	D	14.7
Select	25.8	16.5	30.7	33.3	32.3	43.5	36.7	31.6
Standard	1.5	0.3	0.9	1.0	1.4	0.5	1.5	1.1
Other quality grade or missing	D	D	8.4	4.1	3.2	7.5	D	6.6
Total quality grade	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Yield grade (YG)								
YG 1	6.4	5.2	9.5	8.6	11.3	8.7	4.3	9.8
YG 2	59.2	38.4	39.2	43.6	42.5	38.2	46.6	41.1
YG 3	28.4	46.6	38.9	38.8	39.3	39.0	41.1	38.7
YG 4	2.2	8.5	6.2	5.8	5.4	6.1	4.1	5.8
YG 5, other, or missing	3.8	1.3	6.2	3.2	1.5	8.0	3.9	4.6
Total yield grade	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Branded/certified	3.2	D	19.6	22.1	19.3	35.6	D	19.6
Weight range								
Heavy weight	1.8	D	27.4	17.4	25.6	5.3	D	24.8
Light weight	22.0	D	1.0	0.9	1.5	0.9	D	1.8

Note. D = Results suppressed to maintain confidentiality.

fed/owned cattle, followed by forward contract cattle. Finally, fed cattle sold through direct trade and marketing agreements had the highest percentages in a heavy weight category, and only cattle sold through auctions had a sizeable percentage in a light weight category.

In total, approximately 58% of fed cattle were sold through direct trade;[5] 28% through marketing agreements; 4% through forward contracts; and the remainder through auctions, dealers and brokers, and packer ownership (see Table 2). In addition, approximately 49% of fed cattle were valued on carcass weight with a grid, 36% on liveweight, 13% on carcass weight without a grid, and the remainder through some other method (see Table 2). Based on a comparison of the percentages of cattle sold by type of marketing arrangement and by type of valuation method, we can infer that cash market cattle (most likely direct trade cattle) are frequently sold based on carcass weight basis with a grid. Thus, cattle producers receive some incentive for higher quality through use of grids even for cash market transactions. However, cattle producers are not likely able to negotiate the terms of the grid without use of an AMA or receive premiums for quality characteristics not reflected on a standard grid.

4. EMPIRICAL METHODS AND RESULTS

We began the analysis by conducting an exploratory analysis of quality using individual quality measures. We then developed a composite quality index that provides a measure of the relative value of beef carcasses. Using the composite quality index, we developed models to analyze the relationship between AMAs and quality and between valuation methods and quality. We describe each of the modeling efforts and present estimation results below.

4.1 Analysis of Quality Using Individual Quality Measures

In this subsection, we analyze the relationship between individual measures of quality for fed cattle and the use of marketing arrangements, while controlling for seasonality and the fixed effects of slaughter plants. Specifically, we calculated the percentage of cattle in each lot by yield grade and quality grade and regressed this variable on the procurement method and a set of control variables. The dependent variable (i.e., the proportion of cattle in the lot in each quality and yield grade category) ranges between 0 and 1. A large percentage of observations have values of 0 or 1 because an individual lot might not contain any cattle of a specific quality or yield grade. For example, no cattle were classified as Yield Grade 4 or 5 in approximately 29% of the lots. Because of this feature of the data, we used a two-bounded Tobit model to estimate the following four equations individually:

$$yg12\_pct_{ti} = \max[0, \min(\beta_0 + \boldsymbol{\beta}_1 \mathbf{D\_AMA}_{ti} + \beta_2 D\_beefcattle_{ti} + \boldsymbol{\beta}_3 \mathbf{D\_PLANT}_{ti} + \boldsymbol{\beta}_4 \mathbf{D\_SEASON}_t + u_{ti}, 1)] \quad (1)$$

[5]Transactions through dealers or brokers are combined with the transactions through direct trade because they account for a very small fraction of the total transactions (less than 1%) and are another type of cash market purchase.

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TABLE 2. Descriptive Statistics for the Variables in the Fed Cattle Quality and Valuation Method Difference Models, Using Fed Cattle Purchase Transaction Data, October 2002–March 2005

Variable	Notation	*M*	*SD*	Min	Max
d_direct	Direct trade purchase (1 = yes, 0 = no)	0.58	0.49	0.00	1.00
d_auction	Auction purchase (1 = yes, 0 = no)	D	D	0.00	1.00
d_forward	Forward contract purchase (1 = yes, 0 = no)	0.04	0.20	0.00	1.00
d_packer	Packer owned procurement (1 = yes, 0 = no)	D	D	0.00	1.00
d_marketing	Marketing agreement purchase (1 = yes, 0 = no)	0.28	0.45	0.00	1.00
yg12_pct	% Yield Grade 1 or 2 in the lot	0.53	0.22	0.00	1.00
yg45_pct	% Yield Grade 4 or 5 in the lot	0.06	0.08	0.00	1.00
primechoice_pct	% Prime or Choice quality grade in the lot	0.64	0.24	0.00	1.00
belowselect_pct	% Standard or below quality grade in the lot	0.06	0.11	0.00	1.00
d_beefcattle	Mostly beef breed cattle in the lot (1 = yes, 0 = no)	0.78	0.42	0.00	1.00
qindex	Quality index ($/lb liveweight)	78.90	3.85	55.57	91.52
d_live	Liveweight basis (1 = yes, 0 = no)	0.36	0.48	0.00	1.00
d_carcass_nogrid	Carcass weight basis without grid (1 = yes, 0 = no)	0.13	0.33	0.00	1.00
d_carcass_grid	Carcass weight basis with grid (1 = yes, 0 = no)	0.49	0.50	0.00	1.00
d_other	Other valuation method (1 = yes, 0 = no)	0.02	0.15	0.00	1.00

Note. D = Results suppressed to maintain confidentiality.

$$yg45\_pct_{ti} = \max[0, \min(\beta_0 + \boldsymbol{\beta}_1 \mathbf{D\_AMA}_{ti} + \beta_2 D\_beefcattle_{ti} + \boldsymbol{\beta}_3 \mathbf{D\_PLANT}_{ti} + \boldsymbol{\beta}_4 \mathbf{D\_SEASON}_t + u_{ti}, 1)] \quad (2)$$

$$primechoice\_pct_{ti} = \max[0, \min(\beta_0 + \boldsymbol{\beta}_1 \mathbf{D\_AMA}_{ti} + \beta_2 D\_beefcattle_{ti} + \boldsymbol{\beta}_3 \mathbf{D\_PLANT}_{ti} + \boldsymbol{\beta}_4 \mathbf{D\_SEASON}_t + u_{ti}, 1)] \quad (3)$$

$$belowselect\_pct_{ti} = \max[0, \min(\beta_0 + \boldsymbol{\beta}_1 \mathbf{D\_AMA}_{ti} + \beta_2 D\_beefcattle_{ti} + \boldsymbol{\beta}_3 \mathbf{D\_PLANT}_{ti} + \boldsymbol{\beta}_4 \mathbf{D\_SEASON}_t + u_{ti}, 1)] \quad (4)$$

where *yg12_pct* and *yg45_pct* are the proportions of cattle in the lot that were classified as Yield Grade 1 or 2 (better yield grade), and Yield Grade 4 or 5 (worse yield grade), respectively, and *primechoice_pct* and *belowselect_pct* are the proportions of the cattle that were classified as Prime or Choice (better quality grade) and below the grade Select (worse quality grade), respectively.[6] $\mathbf{D\_AMA}_{ti}$ is a vector of binary variables that indicates the type of marketing arrangement used for purchase of the lot, including direct trade (*d_direct*) (as the base group), auction barns (*d_auction*), forward contracts (*d_forward*), packer owned and other arrangements (*d_packer*), and marketing agreements (*d_marketing*). The $\mathbf{D\_AMA}_{ti}$ coefficients allow a direct test of the association between cattle quality and AMA use. The variable *d_beefcattle* indicates whether the fed cattle are a beef or dairy breed. $\mathbf{D\_PLANT}_{ti}$ is a vector of binary variables that indicates which of the 29 plants bought the lot of cattle. These plant binary variables control for the plant-level unobserved fixed effects, such as location, installed capital equipment, and type of accounting system. Finally, $\mathbf{D\_SEASON}_t$ is a vector of binary variables that indicate the month of the year when the cattle were delivered. The random error term, u_{ti}, is assumed normally distributed and conditional on the explanatory variables. The descriptive statistics of the variables are summarized in Table 2.

Table 3 reports the parameter estimates, $\boldsymbol{\beta}$, for Equations 1 through 4 using approximately 572,000 cattle purchase lots representing approximately 58 million head of cattle for the October 2002 through March 2005 period. The base group of the regressions is direct trade (i.e., the direct trade binary variable was omitted from the regressions). Note that the values in Table 3 do not have the usual marginal interpretation because of the use of the Tobit model. Thus, Table 4 reports the expected difference in the percentage of cattle in a lot by yield grade or quality grade between each type of marketing arrangement. Compared with direct trade cattle, fed cattle sold through auction barns and packer-owned cattle have better quality grades but worse yield grades, forward contract cattle have better yield grades and a slightly larger percentage are classified as Select, and marketing agreement cattle have better quality grades and a slightly larger percentage classified as Yield Grade 3. On average, auction barn cattle have the highest quality grade (22% more are classified as Prime or Choice compared to direct trade cattle) but the lowest yield grade (12% less are classified as Yield Grade 1 or 2 compared to direct trade cattle) among all of the five marketing arrangements. Packer-owned cattle and market agreement cattle

[6]Separate regressions were not run for middle quality cattle (Yield Grade 3 and Select quality grade) because the focus of the analysis is on whether specific types of marketing arrangements are associated with higher or lower than average quality.

TABLE 3. Tobit Parameter Estimates in the Fed Cattle Quality Difference Models, Using Fed Cattle Purchase Transaction Data, October 2002–March 2005

	Coefficient[a] (SE)			
Variable	yg12_pct	yg45_pct	primechoice_pct	belowselect_pct
d_auction	−0.1163	0.0599	0.2508	−0.0223
	(0.0053)	(0.0026)	(0.0053)	(0.0038)
d_forward	0.0111	−0.0054	−0.0097	−0.0090
	(0.0014)	(0.0007)	(0.0014)	(0.0010)
d_packer	−0.0572	0.0182	0.0240	−0.0166
	(0.0016)	(0.0008)	(0.0016)	(0.0012)
d_marketing	−0.0122	−0.0049	0.0219	−0.0258
	(0.0007)	(0.0003)	(0.0006)	(0.0005)
d_beefcattle	−0.0320	0.0344	−0.0117	−0.0144
	(0.0010)	(0.0006)	(0.0011)	(0.0008)
Other variables[b]	Not reported			
No. of observations (lots)	571,608	571,608	571,608	571,608
Likelihood ratio χ^2	192,811	125,389	97,039	101,424
Prob > χ^2	0.0000	0.0000	0.0000	0.0000

[a]All coefficients are significant at the 5% level.
[b]The Other variables include an intercept, monthly (seasonality) binary variables, and plant binary variables.

TABLE 4. Estimated Average Quality Differences Relative to Direct Trade Transactions among AMAs for Fed Cattle Purchase Transactions, Computed at the Means of the Variables (%), October 2002–March 2005

Marketing arrangement	% Yield Grade 1 or 2	% Yield Grade 4 or 5	% Prime or Choice	% Quality Grade lower than Select
Auction	−12.0	4.5	22.0	−1.3
Forward contract	1.1	−0.3	−0.9	−0.6
Packer owned	−5.7	1.2	2.3	−1.0
Marketing agreement	−1.2	−0.3	2.1	−1.5

Note. AMA = Alternative marketing arrangements.

are slightly higher in quality grade (about 2% more are classified as Prime or Choice) than direct trade cattle. Direct trade cattle and forward contract cattle share similar quality grades and yield grades.

The main conclusion from these model results is that beef quality is multi-dimensional; thus, analyses should focus on the combined effects of multiple quality measures. In particular, there is generally an inverse relationship between quality grade and yield grade and a positive correlation between intramuscular fat (marbling) and external fat that increases yield grade. Although most marketing arrangements show some degree of trade-off between quality grade and yield grade, marketing agreement cattle, perhaps because of tighter specifications, include more Prime and

Choice cattle without increases in Yield Grade 4 and 5 and only a modest reduction in Yield Grade 1 and 2. Other results show that auction barn cattle have the highest quality grade but also the lowest yield grade, forward contract cattle have quality measures most similar to direct trade, and packer-owned cattle have similar quality grades compared to marketing agreement cattle but without better yield grades. These initial results indicate that industry is receiving and responding to quality signals through use of AMAs.

4.2 Construction of a Quality Index

In this section, we construct a quality index that summarizes the quality information of each cattle lot into a composite measure using several quality measures. The quality index is used as a dependent variable to explore the relationship between cattle quality and AMAs and the relationship between cattle quality and valuation method. This index incorporates information on quality grade, type of cattle, and whether the cattle are under a certification program. However, yield grade information is not incorporated because yield grade is not a meaningful quality indicator for beef purchased by consumers.[7] Specifically, the quality index (qindex) for each lot is constructed as follows:

$$\begin{aligned} qindex_{ti} = & (prime\_price \times prime\_pct_{ti}) + (choice\_price \times choice\_pct_{ti}) \\ & + (select\_price \times select\_pct_{ti}) + (standard\_price \times standard\_pct_{ti}) \\ & + (qualityother\_price \times qualityother\_pct_{ti}) \\ & + (certified\_premium \times certified\_pct_{ti}) \\ & - (dairycattle\_discount \times dairycattle\_binary_{ti}), \end{aligned} \tag{5}$$

where $prime\_pct_{ti}$, $choice\_pct_{ti}$, $select\_pct_{ti}$, and $standard\_pct_{ti}$ are the percentages of cattle in the lot that were classified as prime, choice, select, and standard, respectively. The variable $qualityother\_pct_{ti}$ refers to the percentage of cattle that were of lower quality than grade Select or were not graded. The variable $dairycattle\_binary_{ti}$ is a binary variable that is set equal to one for fed cattle lots that primarily consist of dairy breeds. The notations and values of *prime_price*, *choice_price*, *select_price*, *standard_price*, *qualityother_price*, *certified_premium*, and *dairycattle_discount* are summarized in Table 5; these values are fixed because they are computed using average market prices that are adjusted for premiums or discounts. Therefore, this quality index should not be influenced by the effects of short-term demand shifters over the time period of the data set. We then can interpret the variable $qindex_{ti}$ as a quality-adjusted average market price for individual lots of cattle.

4.3 Quality Differences Across AMAs Using a Quality Index

Using the quality index described above, we analyze the relationship between fed cattle quality and the use of marketing arrangements, while controlling for seasonality and the fixed effects of slaughter plants. The model is specified as

$$qindex_{ti} = \beta_0 + \boldsymbol{\beta}_1 \mathbf{D\_AMA}_{ti} + \boldsymbol{\beta}_2 \mathbf{D\_SEASON}_t + \boldsymbol{\beta}_3 \mathbf{D\_PLANT}_{ti} + u_{ti} \tag{6}$$

[7]Carcasses with poor yield grades require more trimming of fat by the packer resulting in higher costs to the packer. However, because beef products are trimmed to a fairly uniform standard, consumers do not observe differences in yield grade in final meat products.

TABLE 5. Descriptions and Values for Market Prices, Premiums, and Discounts Used to Construct the Fed Cattle Quality Index, October 2002–March 2005

Variable	Description	Value ($/cwt)
choice_price	Average live fed steer price (Nebraska direct) for Choice grade cattle over the data collection period	83.31
prime_price	*choice_price* plus average premium for Prime grade cattle	90.40
select_price	*choice_price* minus average discount for Select grade cattle	73.35
standard_price	*choice_price* minus average discount for Standard grade cattle	64.83
qualityother_price	*choice_price* minus the average discount for bullocks/stags, hardbone, and dark cutter	57.54
certified_premium	Average premium for certified cattle	1.81
dairycattle_discount	Average discount for fed dairy breed cattle	1.97

and

$$Var(u_{ti}) = \delta_0 + \boldsymbol{\delta}_1 \mathbf{D\_AMA}_{ti} + \boldsymbol{\delta}_2 \mathbf{D\_SEASON}_t + \varsigma_{ti}, \tag{7}$$

where $\mathbf{D\_AMA}_{ti}$, $\mathbf{D\_SEASON}_t$, and $\mathbf{D\_PLANT}_{ti}$ are as defined previously. The summary statistics for $\mathbf{D\_AMA}_{ti}$ are listed in Table 2. The coefficients in Equation 6 indicate the association between each type of marketing arrangement and higher or lower than average cattle quality. The coefficients on $\mathbf{D\_AMA}_{ti}$ in Equation 7 indicate the association between each type of marketing arrangement and cattle quality consistency across lots.

We estimate Equation 6 using ordinary least squares (OLS) estimation. To estimate Equation 7, we run an OLS regression of the squared residuals in Equation 6 on the explanatory variables. Table 6 reports parameter estimates from Equations 6 and 7. The difference in the quality index between any two marketing arrangements can be interpreted as the difference in average market values. The relatively small volume of cattle procured through auction barns was associated with the highest quality relative to other methods ($3.24/cwt higher compared to direct trade), but also with the highest quality variation. Cattle procured through marketing agreements or packer ownership were of higher quality ($0.57/cwt and $0.68/cwt higher compared to direct trade) and had lower quality variances than cattle procured through direct trade. Forward contracts were associated with the lowest quality cattle relative to other methods ($0.19/cwt lower than direct trade), but relatively high quality variances.

4.4 Quality Differences Across Valuation Methods Using a Quality Index

In this section, we analyze the relationship between the fed cattle quality index and valuation method, while controlling for seasonality and the fixed effects of slaughter plants. The model is specified as

$$qindex_{ti} = \beta_0 + \boldsymbol{\beta}_1 \mathbf{D\_VALUATION}_{ti} + \boldsymbol{\beta}_2 \mathbf{D\_SEASON}_t + \boldsymbol{\beta}_3 \mathbf{D\_PLANT}_{ti} + u_{ti} \tag{8}$$

TABLE 6. Ordinary Least Squares Parameter Estimates for the Quality Index Model in Terms of AMAs ($/cwt Liveweight), October 2002–March 2005

Variable	Equation 6 Coefficients[a] (Robust *SE*)	Equation 7 Coefficients (*SE*)
d_auction	3.24 (0.064)	29.50 (0.160)
d_forward	−0.19 (0.019)	−2.98 (0.210)
d_packer	0.68 (0.024)	−0.97 (0.230)
d_marketing	0.57 (0.010)	−1.53 (0.093)
Other variables[b]	Not reported	
No. of observations (lots)	571,608	571,608
F statistic	$F(42,571565) = 9{,}403$	$F(15,571592) = 2{,}412$
Prob > *F*	0.0000	0.0000
R^2	0.2772	0.0595

Note. AMA = Alternative marketing arrangements.
[a]All coefficients are significant at the 5% level.
[b]The Other variables include an intercept, monthly (seasonality) binary variables, and plant binary variables.

TABLE 7. Ordinary Least Squares Parameter Estimates for the Quality Index Model in Terms of Valuation Method ($/cwt Liveweight), October 2002–March 2005

Variable	Equation 8 Coefficients[a] (Robust *SE*)	Equation 9 Coefficients (*SE*)
d_carcass_nogrid	0.15 (0.014)	−5.92 (0.14)
d_carcass_grid	0.46 (0.009)	−2.58 (0.09)
d_other	0.16 (0.026)	−5.64 (0.29)
Other variables[b]	Not reported	
No. of observations (lots)	571,608	571,608
F statistic	$F(41,571566) = 9{,}563$	$F(14,571593) = 194$
Prob > *F*	0.0000	0.0000
R^2	0.2744	0.0047

[a]All coefficients are significant at the 5% level.
[b]The "other variables" include an intercept, monthly (seasonality) binary variables, and plant binary variables.

and

$$Var(u_{ti}) = \delta_0 + \boldsymbol{\delta}_1 \mathbf{D\_VALUATION}_{ti} + \boldsymbol{\delta}_2 \mathbf{D\_SEASON}_t + \varsigma_{ti}, \qquad (9)$$

where $\mathbf{D\_VALUATION}_{ti}$ is a vector of binary variables that indicates the valuation method used for purchasing each lot of fed cattle, including liveweight basis (*d_live*) (as the base group), carcass weight basis without grid (*d_carcass_nogrid*), carcass weight basis with grid (*d_carcass_grid*), and other valuation method (*d_other*). The definitions of $\mathbf{D\_SEASON}_t$, and $\mathbf{D\_PLANT}_{ti}$ are the same as defined previously. The summary statistics for *qindex* and $\mathbf{D\_VALUATION}_{ti}$ are listed in Table 2. The coefficients on $\mathbf{D\_VALUATION}_{ti}$ in Equation 8 indicate the association between

each type of valuation method and higher or lower than average cattle quality. The coefficients on $\mathbf{D\_VALUATION}_{ti}$ in Equation 9 indicate the association between each type of valuation method and higher or lower cattle quality consistency across lots.

Table 7 reports the parameter estimates from Equations 8 and 9. The quality of cattle valued on a carcass weight basis with a grid was higher and more consistent than the quality of cattle valued on a liveweight basis. However, the quality improvement associated with carcass weight valuation without a grid appears to be modest. Compared with cattle valued on a liveweight basis, cattle valued on a carcass weight with grid basis were valued \$0.46/cwt (liveweight) higher because of better quality, and cattle valued on a carcass weight without grid basis were valued \$0.15/cwt (liveweight) higher because of better quality.

5. CONCLUSIONS

The estimation results confirm that beef quality varies systematically across AMAs and valuation methods used for purchasing fed cattle. These results may occur for two reasons. First, cattle producers may have changed their production practices in response to the requirements under different marketing arrangements. Second, producers might not have changed their production practices, but only sorted their marketable cattle according to which marketing arrangement would allow them to maximize their profits. We expect both effects likely exist, but that changes in production practices likely dominate in the long run. If cattle producers are only sorting within the existing cattle population, then average beef quality in the market should not change with increasing use of AMAs. However, empirical evidence has shown that average beef quality in the market increases with increasing use of AMAs in a separate analysis of monthly mandatory price reporting data during April 2001 through December 2005 (see Muth et al., 2007). Therefore, although sorting may be one reason that contributes to our quality and consistency findings, it cannot be the whole story. Our results imply that we should not overlook the change in consumer welfare due to quality changes when analyzing structural change in the beef industry. In particular, we should consider the potential consumer welfare loss that may occur due to decreases in quality if particular types of marketing arrangements or valuation methods that are associated with higher quality are restricted.

We found that fed cattle procured through marketing agreements and packer ownership were of better and more consistent quality than direct trade cattle. This result is consistent with our hypothesis that closer vertical coordination is related to better quality. In particular, marketing agreements provide incentives for production of better quality cattle through a long-term relationship between the buyer and seller. However, we also found that the quality of auction barn cattle was the highest (though least consistent) among all types of marketing arrangements and that cattle procured through forward contracts were similar to those procured under direct trade. The result for auction cattle may be because many fed cattle auctions are specialty auctions often used to sell small lots of high-quality cattle to target particular niche markets. In addition, the result for forward contracts may be because the required coordination between producers and packers under forward contracts is somewhat similar to that under direct trade. Forward contracts are

short-term agreements for a specific lot of cattle with no long-term relationship between the buyer and seller.

Finally, we found that the carcass weight basis valuation method with grid provided better price signals to fed cattle producers than the liveweight basis valuation method. However, the finding of moderate quality differences between cattle priced by the two methods may suggest the need for further refinement of valuation methods used in the fed cattle industry.

The analyses presented above indicate that, at the national level and for the period of the analysis, tighter vertical coordination through use of AMAs and more precise price signaling through use of different cattle valuation methods help improve beef quality because these mechanisms facilitate information exchange enabling producers to respond better to consumer demand. In future work, it would be useful to determine whether the observed effects would be similar in a period in which cattle supplies were more abundant. In particular, because of tight cattle supplies and record high cattle prices in recent years, fed cattle producers have been able to sell cattle at their asking prices without being subject to the same degree of grading risk as in other periods. Furthermore, it would be useful to estimate separate models by region of the country to determine whether the effects vary in the High Plains versus the Cornbelt/Northeast and the West. Although the estimated models included plant-level binary variables that account for some of the regional variation, separate models by region might identify differences in the relationship between marketing practices and quality arising because of differences in the type of cattle sold and competitive behavior among producers in packers in each region. Finally, it would be useful to explore further the interaction between marketing method and use of grid pricing to determine whether improved quality can be obtained through use of grid pricing regardless of marketing method. In conducting such an analysis, it will be important to consider the full range of quality measures in addition to those reflected in the grid pricing structure. In particular, new quality measures such as organic, natural, and age verified are becoming increasingly important in the beef industry.

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