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Risk and Market Participant Behavior in the U.S. Slaughter-Cattle Market

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Incomplete information generates uncertainty for market participants in the slaughter-cattle market. Buyer and seller behavior in the presence of that uncertainty is examined. Statistically significant risk premiums are charged by packers when buying slaughter cattle on either a live- or dressed-weight basis compared to buying on a grade-and-yield basis. Pratt-Arrow risk-aversion coefficients are calculated for buyers and these remain constant over all marketing methods. Sellers market cattle under all three marketing methods, suggesting producers' attitudes toward risk (risk-aversion coefficients) vary.

Key words: cattle-marketing alternatives, risk aversion, risk premiums

Introduction

Incomplete information on product quality creates risk in a market transaction. Numerous researchers have documented that market participants react differently in a risky situation depending upon their attitudes toward risk (Raskin and Cochran; Wilson and Eidman; King and Robinson). These studies have classified agricultural market participants according to the Pratt-Arrow risk-aversion coefficients into three categories: risk averse, risk neutral, and risk preferring.

Three main cash-marketing methods are currently available to U.S. slaughter-cattle producers: (a) live weight, (b) dressed weight (in-the-beef), and (c) dressed weight and grade (grade and yield). Information available on product quality varies depending upon the marketing method used. The degree of uncertainty associated with buying and selling cattle in each of these marketing methods also varies with the amount of information available on product quality.

A recent paper by Feuz, Fausti, and Wagner reported that producers' profits differed among the live-weight, dressed-weight, and grade-and-yield marketing methods for slaughter cattle. They indicated that profits, on the average, were highest with the grade-and-yield marketing method and lowest with the live-weight marketing method. They also found that the variance of producer profits (risk) was greatest for grade-and-yield marketing and smallest for live-weight marketing.

The objectives of this research are to determine the effect of uncertainty associated with incomplete information across marketing methods on (a) the market price for slaughter cattle and (b) buyer and seller behavior. Results reported in this article should provide additional insight into the U.S. slaughter-cattle market and be helpful to those looking to modify existing marketing methods or to create new value-based marketing methods.

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U. S. Slaughter-Cattle Market

Ward found that, in 1979, 98% of cattle in the southern plains and 82% of cattle in the western corn belt were marketed on a live-weight basis. Carcass weight pricing accounted for an additional 1% and 18% of the sales in the two regions, respectively. By 1990, carcass-based sales had increased to 28% of the sales in the southern plains and to 45% of sales in the corn belt (Packers and Stockyards Administration). One of the "big three" meatpackers reported that, in 1993, it purchased 30% of its cattle grade and yield, 57% dressed weight, and 13% on a live-weight basis for two of its plants located in the corn belt (Feuz).

Sellers often have a choice of marketing method. However, buyers (meatpackers) may not always be willing to purchase cattle under all three methods. For example, in the spring, when lots are often muddy, buyers may not want to accept the risk of estimating dressing percentage, thus, may not purchase cattle on a live-weight basis.

Several factors may influence a seller's choice of marketing method. Payment is delayed at least one day with grade-and-yield marketing, and many producers do not understand grade-and-yield pricing. There is also an element of mistrust of the packers and a fear that their cattle may be mixed with inferior cattle and priced accordingly. These factors add to the risk, or to the perceived risk, faced by sellers when choosing a marketing method.

Additionally, the United States Department of Agriculture (USDA) quality and yield grades have been criticized for not capturing all of the value differences of slaughter cattle. This has prompted research into alternative value-based marketing methods and/or changes to the current grading system. However, under present slaughter-cattle marketing methods, the grade-and-yield method represents the full-information method from the buyer's (meat-packer's) perspective. To the extent that the grade-and-yield price does not reflect the true value of the carcass, that bias would remain in the dressed-weight and live-weight marketing methods, since prices in those markets are based on buyers' and sellers' estimates of the USDA quality and yield grades.

With grade-and-yield marketing, the price paid to the seller is based on the actual carcass weight and the USDA quality and yield grades of that carcass. If cattle are marketed dressed weight, the carcass weight is known with certainty, but buyers must estimate the expected quality and yield grades. When cattle are marketed on a live-weight basis, the buyer must estimate the dressing percentage (dressing percentage = carcass weight/live weight) and the quality and yield grades. Ward provides a more detailed description of the three marketing methods and the information available with each method.

Theory

If there were full information across all marketing methods, then the U.S. slaughter-cattle market would be efficient: the price of the input (slaughter cattle) would equal its marginal value product in the production of beef and beef by-products. Since the production process does not change with marketing method, the marginal value product of an animal would be the same and the price offered would be identical across marketing methods. The distribution of revenue received by sellers also would be equal, regardless of marketing method. However, the structure of the market is such that there is *not* full information across the marketing methods, nor is this incomplete information distributed equally.

Research by Fausti and Feuz has shown that the mere introduction of uncertainty over the quality of a factor will reduce the marginal value product of that factor compared to the

certainty case. They demonstrate that the same quality cattle marketed live or dressed weight will have a lower marginal value product as compared to the grade-and-yield alternative. A risk-neutral, profit maximizer would offer lower prices in the live- and dressed-weight marketing methods. Fausti and Feuz also demonstrate that as the level of buyer risk aversion increases, the magnitude of the price differential increases.

Ward provides a similar argument that a buyer's risk—risk with respect to incomplete information on the marginal productivity of the cattle—increases from grade-and-yield to dressed-weight to live-weight marketing and that buyers offset that risk by offering a lower price in the live-weight and dressed-weight markets. Ward's argument is consistent with the theoretical results derived by Fausti and Feuz and with the factor market literature (Hey) when quality uncertainty is the issue.

Pratt has shown that the risk premium is equal to one-half the variance of the risk times the absolute risk-aversion coefficient. Assuming that buyers' (meatpackers') risk-aversion coefficients remain constant, the size of the risk premium will increase with increased levels of risk. It follows that the live-weight marketing method will have a greater risk premium than the dressed-weight marketing method.

The risk to the buyer increases from grade-and-yield to dressed-weight to live-weight marketing, but the risk to the seller decreases. With live-weight marketing, the seller knows with certainty at the time of sale the total revenue from any pen of cattle. However, with dressed-weight or grade-and-yield marketing, revenue is uncertain.

Sellers' revenue per head under each marketing method is defined as:

- (1)
$$LREV = \text{Live Price} \cdot \text{Live Weight},$$
- (2)
$$E(DREV) = \text{Dressed Price} \cdot \text{Live Weight} \cdot E(\text{Dressing Percent}), \text{ and}$$
- (3)
$$E(GYREV) = E(\text{GY Price}) \cdot \text{Live Weight} \cdot E(\text{Dressing Percent}),$$

where E is the expectations operator; $LREV$, $DREV$, and $GYREV$ are revenue from marketing live weight, dressed weight, and grade and yield; and $GY Price$ is the grade-and-yield price. The risk to sellers is that the actual revenue from dressed-weight or grade-and-yield marketing is not equal to the expected revenue because the dressing percentage and/or the quality and yield grades and the associated grade-and-yield price of the cattle were other than expected. The risk for buyers comes by incorrectly estimating the quality and yield grades and offering a price that is not in line with the actual quality of the cattle, and in the case of live-weight marketing, incorrectly estimating the dressing percentage and paying for more or less carcass weight than actually exists.

Since cattle are marketed under all three marketing methods, and sellers have some choice in the marketing method used, and if risk premiums vary with marketing method, then (a) sellers' absolute risk-aversion coefficients are equal to that of buyers, or (b) some sellers are more risk averse (larger absolute risk-aversion coefficient) and some sellers are less risk averse than buyers. In the case of equal risk-aversion coefficients, sellers would be indifferent to the revenue and risk trade-off from each marketing method and would make the marketing decision based on other criteria. Sellers who are more risk averse than buyers

¹Slaughter cattle sold on a live-weight basis are often sold with a "pencil" shrink on live weight. A 4% pencil shrink is fairly common and was used in this analysis.

would prefer a lower, more certain revenue case and would choose the live-weight marketing method. Sellers who are less risk averse than buyers would prefer the uncertain case with higher expected revenue and would choose the grade-and-yield marketing method. A more detailed exposition of market behavior under uncertainty can be found in McKenna (pp. 32–8).

Data and Procedure

Data

Detailed data were collected on 69 pens of steer calves in 1991 and 84 pens of steer calves in 1992 as part of a retained-ownership demonstration project (Wagner et al. 1991, 1992). The steers came from more than 100 different operations and three states. Steers were marketed on a grade-and-yield basis in the spring, when 60% in each pen were estimated to have 0.4 inches of fat over the twelfth rib. Summary statistics on the slaughter characteristics of these steers are presented in table 1.

The choice market price and discounts for select carcasses (\$2–8/cwt), yield grade 4 carcasses (\$10–12/cwt), carcasses over 950 pounds (\$10/cwt), and carcasses under 550 pounds (\$12/cwt) were negotiated with a commercial cattle buyer in a competitive market. The average live- and dressed-weight market prices for similar types of steers were obtained from market quotes² and revenue per head was calculated as if the steers had been sold under all three marketing methods. Market prices for the various marketing dates and marketing methods are shown in table 2. The distribution of revenue per head from each marketing method is presented in table 3. Data are most representative of the upper-midwest and western corn-belt regions of the U.S. and are limited to the March–through–June marketing time frame.

Table 1. Summary Statistics for the Slaughter Characteristics of the 744 Steers in the Data Set

Characteristic	Mean	SD	Range
Live Slaughter Weight (lbs.) ^a	1122.96	104.1137	804.00 – 1406.00
Hot Carcass Weight (lbs.)	717.85	73.6929	464.00 – 936.00
Dressing Percent (%)	63.89	1.9107	57.39 – 70.43
USDA Yield Grade	2.38	0.4921	1.00 – 4.00
USDA Quality Grade (% Choice)	40.99 ^b		

^aLive weight less a 4% "pencil" shrink from the actual live weight.

^bThe USDA Quality Grade is coded as a 1 for choice or higher and as a 0 for select or lower grades. The mean is the proportion of the total population that graded choice or above. No standard deviation or range is shown for this 0/1 variable.

²Steers were slaughtered at the IBP plant located in Luverne, Minnesota. Hartman indicated the cattle from the project were representative of the cattle being purchased in the general market area. Prices paid for steers at the Luverne plant are typically \$1/cwt lower on a carcass basis than for similar steers at IBP's plant in Dakota City, Nebraska. The Nebraska Direct dressed- and live-weight market prices were obtained from Data Transmission Network and the USDA, *Livestock, Meat, and Wool Market News*, and were then adjusted downward for the Luverne basis by \$1/cwt and \$0.64/cwt for dressed and live weight, respectively

Risk and Behavior

To test the assumption that buyers of cattle offset the risk associated with lack of information on dressing percentage and cattle quality by offering lower prices in the live- and dressed-weight marketing methods, the following two testable hypotheses are set forth: (a) there will be a significant risk premium charged to the seller in both the live- weight and dressed-weight marketing methods; and (b) the risk premium will be greater with live-weight than dressed-weight marketing. The expected value of the risk premiums for live- and dressed-weight marketing methods are defined as follows:

$$(4) \quad LRP = \left(\sum_{i=1}^n GYREV_i - LREV_i \right) / n, \text{ and}$$

$$(5) \quad DRP = \left(\sum_{i=1}^n GYREV_i - DREV_i \right) / n,$$

Table 2. Market Prices (\$/cwt) for Various Marketing Dates and Alternative Marketing Methods

Marketing Date	Live ^a	Grade and Yield		Select ^c
		Dressed ^b	Choice ^c	
10 April 1991	80.96	127.00	130.00	125.00
2 May 1991	79.57	125.50	129.00	122.00
8 and 9 May 1991	78.81	124.00	128.00	120.00
20 June 1991	73.59	115.00	119.00	111.00
31 March 1992	77.97	124.00	125.00	123.00
14 April 1992	78.40	123.00	126.00	124.00
23 April 1992	76.44	120.00	122.00	119.00
19 May 1992	75.97	118.50	125.00	119.00

^aData Transmission Network Corporation.

^bU. S. Department of Agriculture.

^cActual competitive grade-and-yield price received for the cattle.

Table 3. Mean, Standard Deviation, and Coefficient of Variation of Revenue per Head for the 744 Steers with Each Marketing Method

	Live Weight	Dressed Weight	Grade and Yield
Mean	873.240	876.910	879.460
Standard Deviation	62.940	71.590	74.080
Coefficient of Variation	0.072	0.082	0.084

where *LRP* and *DRP* are the live-weight and dressed-weight risk premiums, respectively; *LREV_i*, *DREV_i*, and *GYREV_i* are the average revenue per head associated with a pen of cattle marketed under the live-weight, dressed-weight, and grade-and-yield marketing methods; and *n* is the number of pens of cattle marketed.

The live-weight risk premium can be separated into the risk premium associated with dressing percentage uncertainty and the risk premium associated with quality and yield grade uncertainty by subtracting (5) from (4), or by calculating the dressed- to live-weight risk premium as follows:

$$(6) \quad LDRP = \left(\sum_{i=1}^n DREV_i - LREV_i \right) / n.$$

The specific testable hypotheses are then:

$H_0: LRP = 0$	$H_1: LRP > 0$
$H_0: DRP = 0$	$H_1: DRP > 0$
$H_0: LRP = DRP$	$H_1: LRP > DRP$

They will be tested using the difference between population means: matched pair test (Newbold, pp. 377–80). The distribution of the risk premiums is assumed normal and the appropriate test statistic is a one sided *t*-statistic.

From the theoretical discussion, it was hypothesized that risk to the buyer decreased and risk to the seller increased from live- to dressed-weight to grade-and-yield marketing. The risk is due to uncertainty of the dressing percentage and of the quality and yield grades. An approximation of this risk can be measured by calculating the variance of the paired revenue differences used to calculate the risk premiums in equations (4)–(6).

The variance of the *LRP* in (4) is due to the variability in dressing percentage, quality grade-and-yield grade, compare (1) vs. (3). The variance of the *DRP* in (5) is associated with the variability of quality and yield grades, compare (2) vs. (3), and the variance of *LDRP* in (6) is associated with the variability in dressing percentage, (1) vs. (2).

Pratt has shown that the risk premium is equal to one-half the variance of the risk times the absolute risk-aversion coefficient. In the context of this article, the risk premiums between marketing methods can be expressed as:

$$(7) \quad LRP = \text{var}(LRP)r / 2,$$

$$(8) \quad DRP = \text{var}(DRP)r / 2, \text{ and}$$

$$(9) \quad LDRP = \text{var}(LDRP)r / 2,$$

where *r* is the absolute risk-aversion coefficient.

Equations (7)–(9) can be rearranged, as follows:

$$(10) \quad r = 2LRP / \text{var}(LRP),$$

$$(11) \quad r = 2DRP / \text{var}(DRP), \text{ and}$$

$$(12) \quad r = 2LDRP / \text{var}(LDRP),$$

to solve for the absolute risk-aversion coefficient of buyers. As the level of variance (risk) changes between the marketing methods, the risk premium should change, but r , the absolute risk-aversion coefficient, should remain constant.

Results

Risk Premium Results

The average risk premiums were calculated using equations (4)–(6) with the above-mentioned data. The average risk premiums were then used to conduct hypothesis tests to determine if the average risk premiums were statistically different from zero. Evidence from the tests provides strong support for nonzero risk premiums in all cases. The results are displayed in table 4.

The tests found the following: (a) a statistically significant risk premium of \$6.22 per head was charged, on the average, by buyers purchasing cattle in the live-weight market instead of the grade-and-yield alternative; (b) the risk premium buyers charged for purchasing in the dressed-weight market instead of the grade-and-yield alternative was \$2.55 per head; and (c) the risk premium buyers charged for purchasing on a live-weight basis instead of the dressed-weight alternative was \$3.67 per head.

From these risk premiums, it appears buyers perceive a greater risk in estimating dressing percentage than in estimating quality and yield grades. For example, the average dressed price during the study was \$122.13 per cwt, and estimating a dressing percent of 64 when actual dressing percent is 62 would mean an overpayment of \$29.31 per head for a 1200-pound steer. Estimating a pen of steers to grade 50% choice when only 40% actually graded choice would have been an overpayment of only \$3.84 per head, based on a 750-pound carcass weight and the actual choice and select prices observed during the study.

To summarize, the following theorized statements are supported by the empirical evidence provided: (a) buyers of cattle charge a risk premium in the live- and dressed-weight marketing methods; and (b) the risk premium increases as the risk to buyers increases.

Calculated Risk-Aversion Coefficients

The results of estimating the Pratt-Arrow risk-aversion coefficients using equations (10)–(12) are presented in table 4. All calculated risk-aversion coefficients are positive and equal, indicating that buyer risk-averse behavior did not change across marketing methods. This was the expected result.

A number of empirical studies can be found in the agricultural economics literature on estimated risk-aversion coefficients (Raskin and Cochran; Elam; Holt and Brandt). Elam used absolute risk-aversion coefficients for leveraged cattle feeders who would choose to forward contract versus hedge their slaughter cattle, reporting risk-aversion coefficients of 0.02 to 0.08. Holt and Brandt used risk-aversion coefficients for various hog-hedging strategies and reported decision makers as “risk averse” with risk-aversion coefficients of 0.02 to 0.04. Those with risk-aversion coefficients of 0.08 to 0.10 were classified as “highly risk averse.”

Raskin and Cochran raised the issues of classifying decision makers based on the value of the Pratt-Arrow risk-aversion coefficient and how the magnitude of the underlying distribution can affect this classification. However, the magnitude of the underlying distri-

Table 4. Risk Premiums, Variances of Revenue Differences, and Pratt-Arrow Absolute Risk-Aversion Coefficients Associated with Alternative Marketing Methods

Marketing Methods	Risk Premium(\$) ^a	Variance of Revenue Differences	Risk-Aversion Coefficient
Live vs. Grade and Yield	6.22**	586.35	0.02
Dressed vs. Grade and Yield	2.55*	206.75	0.02
Live vs. Dressed	3.67*	340.37	0.02

^aOne asterisk (*) and two asterisks (**) denote premiums which are significantly different from zero at the 0.05 and 0.01 level, respectively.

butions from this study is similar to the two studies by Elam and by Holt and Brandt, allowing for some comparison of the estimated risk-aversion coefficients. Based on the Holt and Brandt classification it would appear that cattle buyers are on an average "risk averse."

Risk to Sellers

Revenue to sellers in the live-weight marketing method is known with certainty when the cash-market transaction takes place (1). However, on the average, sellers can expect a higher revenue from both the dressed-weight and grade-and-yield marketing methods. Yet, as Packers and Stockyards Administration data indicate, many sellers still use the live-weight marketing method. This behavior on the part of sellers is a departure from the theory of individual profit maximization. However, as noted previously, many sellers distrust meat-packers and/or do not fully understand grade-and-yield pricing. This distrust adds to the risk, or perceived risk, of the grade-and-yield marketing method. Risk aversion and utility of profit maximization rather than profit maximization can rationally explain seller behavior in choosing the live- or dressed-weight marketing method.

If sellers are not risk neutral, then both the expected value of the return and the degree of risk associated with that level of return are important considerations in the marketing decision. The mean, standard deviation, and coefficient of variation of revenue for each marketing method are displayed in table 3. Returns do increase going from live-weight to dressed-weight to grade-and-yield marketing, but the risk also increases.³ Not only do the standard deviations increase, but the level of risk proportional to the mean increases, as measured by the coefficients of variation of 0.072, 0.082, and 0.084 for the live-weight, dressed-weight, and grade-and-yield methods, respectively.

Cattle feeders who have the least aversion to risk would be more likely to market cattle grade and yield and receive a higher average return. Producers who have the greatest level of risk-aversion would be more likely to market cattle on a live-weight basis. Given the reported risk-aversion coefficients of cattle feeders from the Elam study and the packer's risk-aversion coefficient estimated in this article, varying degrees of risk aversion provide a reasonable explanation for the percentage breakdown of cattle marketed in each method

³The variation in revenue is based on variations in weight, dressing percentage, quality grade, and yield grade of the cattle in this data set. Actual variations in market returns also would include variations in prices offered. This is a limitation of the data set. Additional research, accounting for variations in prices offered, could substantiate or refute the findings of this article.

reported by Ward, Packers and Stockyards Administration, and Feuz. It is probable that some producers are less, equally, and more risk averse than meatpackers.

Conclusions

This study presents an analysis of the risk associated with incomplete information over alternative slaughter-cattle cash-marketing methods. Buyer and seller behavior in the presence of that risk is of particular interest. Data from the upper-midwest and western corn-belt regions of the U.S. were used to test the hypothesis that buyers would charge a risk premium with live- and dressed-weight marketing methods compared with the grade-and-yield marketing method. The risk to buyers purchasing under live-weight, dressed-weight, or grade-and-yield pricing was approximated, as well as the level of absolute risk aversion.

Statistically significant risk premiums were found to be charged by packers when buying slaughter steers on either a live- or dressed-weight basis compared with buying on a grade-and-yield basis. The risk premium for live marketing averaged \$6.22 per head; the risk premium for dressed marketing averaged \$2.55 per head. There is more risk in correctly estimating the carcass characteristics on a live basis; this is reflected in the premium. The results substantiated the hypothesis that cattle buyers would charge a risk premium in the live-weight and dressed-weight marketing methods.

Specific Pratt-Arrow risk-aversion coefficients were calculated for buyers based on the risk premiums charged and variance of the risk for each marketing method. These risk-aversion coefficients were all 0.02. The level of risk did not change the level of risk aversion—it only affected the magnitude of the risk premium being charged. This result is consistent with the literature on uncertainty.

The risk to sellers, variability of returns, increases going from live-weight to dressed-weight to grade-and-yield marketing. Grade-and-yield marketing produces the highest expected revenue, and live-weight marketing produces the lowest average revenue of the marketing methods.

This study provides empirical evidence that uncertainty of product quality affects the pricing and marketing decisions of participants in the slaughter-cattle market. In summary, (a) buyers charge a risk premium in the live-weight and dressed-weight marketing methods; (b) buyers are on the average "risk averse;" and (c) varying levels of risk aversion among sellers offer one explanation for the use of all three slaughter-cattle marketing methods.

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