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Beef Quality: Will Consumers Pay for Less Fat?

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A nationwide retail survey is used to estimate hedonic prices of fat characteristics in beef table cuts. Results show that consumers consistently place a negative value on external fat for all table cuts and on seam fat in chuck and round cuts, but do not consistently value intramuscular fat. These consumer preferences are not transmitted to cattle feeders through price signals, even though the current beef grading system can distinguish carcasses with undesirable fat characteristics.

Key words: beef demand, demand for characteristics, hedonic prices.

Introduction

Nutrition experts have told Americans to reduce consumption of saturated fat to avoid heart disease and cancer (National Research Council), and to do so by cutting beef intake. This health advice is often cited as the cause of an apparent decline in beef demand (e.g., Purcell), although convenience and price competition from chicken are also recognized as important factors (e.g., Eales and Unnevehr). Nevertheless, the beef industry has taken several steps to meet a perceived demand for leaner beef. Part of the industry's promotional campaign focuses on selling lean beef as part of a healthy diet. In 1986, most major retailers adopted a quarter-inch trim standard for the external fat on beef table cuts (Savell et al.). In 1988, the U.S. Department of Agriculture (USDA) changed its grading nomenclature to allow promotion of "Select" grade beef, which is leaner than the more common "Choice" grade ("USDA Adopts . . .").

Yet whether consumers will pay for reductions in the fat content of beef is unknown. Consumer preferences could vary by beef product and fat location. For example, marbling (intramuscular fat) can contribute to palatability and taste, but seam fat creates tough pockets of gristle. External fat could contribute to palatability, but consumers may view it as unattractive waste. Consumer preferences for characteristics of beef products have important implications for efforts to promote lean beef, to change beef grading, or to alter the characteristics of cattle through genetic improvement.

In this article, we use data from the National Beef Market Basket Survey (Savell et al.) to directly measure consumers' willingness to pay for different fat characteristics. We test the hypothesis that consumers value beef fat according to beef product type and where fat is located in the cut. We first present the empirical model, taken from the literature on demand for quality characteristics. The results of hedonic price estimates are reviewed and interpreted. We conclude with a discussion of the implications for the organization and efficiency of beef marketing.

Consumer Demand for Quality

Several authors have proposed an alternative view of consumer demand in which consumers derive utility or satisfaction from the characteristics that goods possess, rather

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than the goods themselves (Becker; Griliches; Lancaster; Rosen; Lucas). Applications of this hedonic price model include measurement of the value of food nutrients to consumers (Ladd and Suvannunt) and evaluation of grading systems (Espinosa and Goodwin).

Ladd and Suvannunt, drawing on Lucas, developed a hedonic price model that has assumptions suited to analyzing food demands. In their model, the amount of a characteristic obtained from each good is fixed to the consumer (and variable to the producer), and the consumer determines the quantities of goods consumed. Hedonic prices are not required to be nonnegative as they are in Lancaster's earlier model.

Ladd and Suvannunt (p. 505) show that

$$p_i = \sum_{j=1}^{m} \left(\frac{dX_{oj}}{dq_i}\right)\left(\frac{dU/dX_{oj}}{dU/dE}\right), \tag{1}$$

where p_i is the market price of product i, X_{oj} is the total amount of the mth product characteristic provided by consumption of all goods, q_i is the amount consumed of product i, and E is total expenditure. The marginal yield of the jth product characteristic by the ith product is dX_{oj}/dq_i. The marginal utility of the jth product characteristic is dU/dX_{oj}, and dU/dE is the marginal utility of income. Therefore, the ratio in brackets is the marginal rate of substitution between income and the jth product characteristic.

If expenditure is assumed equal to income, the bracketed term is also the marginal implicit price of the jth characteristic. Equation (1) states that the product price paid by the consumer equals the sum of the marginal values of the product's characteristics. Each value is equal to the quantity of the characteristic obtained from a marginal unit of the product multiplied by the marginal implicit price of the characteristic.

Because the yield of most product characteristics is constant for each unit of product, $dX_{oj}/dq_i = X_{ij} = \text{constant}$ is assumed. Furthermore, the marginal implicit price is also assumed to be constant and is represented by P_{ij}. Therefore, equation (1) for a particular product, F, becomes

$$P_F = \sum_{j=1}^{m} X_{Fj}P_{Fj}. \tag{2}$$

The addition of a random error term to equation (2) provides the familiar equation used to estimate hedonic prices, P_{Fj}, from observations of characteristics, X_{Fj}, and market prices, P_F, of different qualities of good F.

The National Beef Market Basket Survey

The beef retail cases of supermarkets in 12 cities were surveyed by a team from Texas A&M University during October/November 1987 and February/March 1988 (see Savell et al. for further details). The cities were selected to represent all regions of the country, and two or three retail chains per city were selected to represent at least one-third of sales.[1] A total of 3,719 beef table cut samples were taken in the stores. For these samples, price per pound, total price, weight, measured width of external fat, whether the cut was bone-in, and a visual assessment of marbling and seam fat percentage were recorded.

In order to analyze the beef cut data, some assumptions must be made regarding the substitutability among cuts. Do consumers apply the same quality criteria to all cuts or are some cuts evaluated differently from others? Lucas demonstrated that estimating a hedonic price function for one class of commodities requires the assumption that the utility function defined in commodity space is separable. Thus the assumption that consumers evaluate products differently is equivalent to assuming that some beef products are weakly separable from others. Eales and Unnevehr used aggregate market data to test for separability between beef table cuts and hamburger, and could not reject it. Their separability test results for beef and chicken products suggested that consumers are mo-

Table 1. Average Characteristics of Different Classes of Beef Table Cuts

Class of Beef Table Cuts	No. Observ.	Price per Pound (¢)	External Fat Thickness (hundredths in.)	Marbling Percent	Seam Fat Percent	Percent Sold Bone-in
Chuck Roasts	336	200.52	12.74	6.00	5.74	38
Chuck Steaks	336	247.36	7.84	6.11	5.15	26
Round Roasts	309	259.07	14.24	4.36	2.01	2
Round Steaks	827	306.19	8.63	4.08	1.32	6
Rib Steaks	315	469.26	10.50	5.68	7.94	34
Loin Steaks	539	490.93	21.04	5.58	3.45	56
Sirloin Steaks	221	356.64	21.26	4.67	2.83	32
Miscellaneous	780	281.41	2.44	5.78	3.84	29

tivated to select products more for their characteristics as inputs into the household production function than for their animal origin.

Different beef cuts provide different kinds of inputs into the household production function, and these must be combined with differing amounts of labor or household capital to produce a meal. For example, round steak has little marbling and is usually cooked in a braised dish like swiss steak, while a sirloin steak with more marbling can be grilled. Roasts take longer to cook and feed more people; steaks take less time and can be purchased in smaller portions. Household size and opportunity cost of the meal preparer's time will determine the initial choice of what type of cut to buy.

We assume that consumers first choose a product type determined by primal location (chuck, rib, loin, round) and by whether the cut is a steak or a roast, and then choose among these similar cuts on the basis of quality characteristics. Thus we divided the beef table cut samples into seven categories for the roast and steak cuts from the four major primals that had large numbers of observations, and an eighth category for the remaining miscellaneous cuts.

Table 1 shows the eight classifications of beef table cuts and the average characteristics for each. Price per pound varies across the primals, with the most expensive products coming from the rib and loin, followed by the round and chuck. Fat content and type of fat varies across primals as well. External fat is thickest for loin steaks and roasts from the chuck and round primals. Rib and chuck cuts have higher proportions of seam fat. Marbling percentage varies less widely than the other characteristics, but is higher for the chuck cuts and the loin steaks. Bone-in products are found in all nine categories, but tend to be a larger proportion of loin steaks. Very few round cuts are sold with bone-in.

Results of Hedonic Price Estimation

The hedonic price model above requires the implicit assumption that all price variation is due to differences in quality characteristics. In this sample, price variation may also occur due to time of sampling and location.[2] Thus the empirical model includes dummy variables for these factors. This equation was estimated for each of the eight product categories of beef table cuts:

$$(3) \quad P = a + bT1 + \sum_{i=1}^{10} c_i C_i + dB1 + eFATHIN + fSMFTPCT + gMARBPCT + u,$$

where P is price per pound, $T1$ is a dummy which equals 1 for the 1987 samples, the C_i are dummies for 10 of the 12 cities,[3] $B1$ is a dummy which equals 1 if the sample is bone-in, $FATHIN$ is external fat thickness in hundredths of inches, $SMFTPCT$ is the percentage

Table 2. Implicit Prices of Beef Quality Characteristics (¢/lb.)

Class of Beef Table Cuts	Bone-in	External Fat Thickness	Marbling Percent	Seam Fat Percent	Adjusted R^2
Chuck Roasts	−42.52	−.91	−4.12	−2.59	.56
Chuck Steaks	−75.92	—	—	−2.48	.54
Round Roasts	—	−1.19	—	−7.51	.23
Round Steaks	—	−1.22	—	−6.02	.22
Rib Steaks	−110.76	−1.76	—	—	.50
Loin Steaks	−90.80	−2.26	5.53	—	.51
Sirloin Steaks	−29.94	−1.47	—	—	.62
Miscellaneous	−141.61	−2.29	—	—	.41

Notes: Coefficients are reported only if significant at the 5% level or better. The complete regression results are in appendix table A1.

of the cut consisting of seam fat, *MARBPCT* is the percentage of the cut consisting of intramuscular fat (marbling), and *u* is a random error. The last four variables are physical measures of quality, and their coefficients give the marginal implicit prices of these quality characteristics.

Table 2 reports coefficients of the beef table cut quality variables; the complete regression results are in appendix table A1. As multicollinearity is often a problem in hedonic price estimation, the Belsley, Kuh, and Welsch diagnostics were generated. These showed condition indices no higher than 19 for any regression; thus the estimates are not degraded by multicollinearity. However, White's test for heteroskedasticity was significant for all regressions, as the variance of the residuals differed widely by location. The standard errors from OLS are biased and inconsistent, so these were corrected using White's heteroskedasticity consistent covariance matrix. Significance levels in table 2 are based on the corrected standard errors reported in appendix table A1.

Four conclusions emerge from the regression coefficients. The first is that the presence of a bone in the cut reduces value sharply. The exception is the round cuts, which did not have many observations with bone-in. The second general result is that more external fat reduces value. A reduction in external fat of one one-hundredth of an inch increases product value by 1 to 2¢ per pound. Third, seam fat has a significant negative value for products from the chuck and round primals, but not for the other primals. Fourth, marbling does not have a consistent value across primals. It has negative value for chuck roasts, but positive value for loin steaks. In summary, fat clearly has negative value on the exterior of beef table cuts, and in seams of chuck and round cuts. Intramuscular fat, or marbling, does not have a consistently negative value; it is not a significant determinant of price for most beef table cuts.

The average consumer places a positive value on marbling in steaks, but this characteristic is not statistically significant for most cuts. This result may be due to the fact that marbling varies less than other quality characteristics in the sample. Another possible explanation is that preferences for marbling differ across the population—some consumers seek leaner beef, while others are indifferent or prefer greater palatability. Consumers seeking leaner beef will achieve greater reductions in fat intake by choosing leaner cuts than by choosing leaner quality of the same cut ("USDA Adopts . . ."). Those choosing loin steaks have already decided to eat a relatively fatty product, and will look for greater palatability rather than leanness.

Implications of the Results for Beef Marketing

Consumers are willing to pay for a reduction in external fat on beef cuts.[4] The challenge for the beef industry is to deliver beef with less external fat. Currently, external fat is trimmed off in the store, which is more costly than reducing external fat initially produced on beef carcasses. Cattle producers will deliver carcasses with less external fat if they receive price premiums for less external fat at the producer level. Effective price transmission from the retail level to the producer depends on the grading and pricing system for beef.

The current grading system allows identification of animals that would produce cuts with less external fat. Cattle can be graded for yield, which is a function of cutability, or the amount of red meat that a carcass will yield (McCoy and Sarhan). Animals with higher cutability receive a lower numbered yield grade. A major determining factor of yield grade is the amount of backfat on the carcass, which is directly related to external fat on beef cuts. Carcasses that have lower numbered yield grades thus would provide beef products with less external fat, and also less undesirable seam fat in the chuck and round primals (National Cattlemen's Association).

Industry surveys report that retail price signals for reduced backfat are not fully transmitted back to the producer level (National Cattlemen's Association; Cattle-Fax). Boxed beef is priced based on a standard one-inch trim for external fat, and thus further trimming is necessary at the retail level. The one-inch trim standard results in discounts for yield grade 4 cattle, but no significant discounts for yield grade 3 cattle, as they will satisfy that standard. Pricing in this manner rewards backfat, since it is valued the same as meat for animals that receive yield grade 3 or better. Producers will only have an incentive to reduce backfat below one inch if they receive a price premium for carcasses with yield grades 1 or 2.[5]

This failure to pass incentives through from the retail level to the producer has been identified by the industry as a problem (National Cattlemen's Association), and the pricing system is changing. In response to consumer signals, retailers are trimming external fat on beef cuts to ⅛ inch or even less. The industry is moving towards a ¼-inch trim standard for boxed beef, and some packers are experimenting with pricing live cattle based on cutability. The results reported in this study show that consumer preferences were evident at least as early as 1988, when the National Beef Market Basket Survey was conducted. Thus, one must ask why the market is moving so slowly to reflect price signals for quality.

This market failure must be evaluated in the context of the changing structure of beef packing and processing. This subsector became highly concentrated during the 1980s, following new investments in larger packing plants (Ward). There is also increasing vertical integration between packing and cattle feeding (Johnson et al.). During the recent low inventory years of the cattle cycle, packers were more interested in purchasing enough cattle to cover the fixed costs of operating a plant than in differentiating among the cattle that they received. As the incentives to improve cutability become more apparent at the packer level, the pressure to price live cattle according to cutability will increase. One possible response would be increased vertical integration (packer ownership of cattle) to reduce the transactions costs of obtaining animals with better cutability.

Conclusions

Improving quality could have important benefits for the beef industry and for consumers, because reducing the amount of a negative attribute is equivalent to shifting the demand curve outward (Unnevehr). Our results show that consumers clearly value reductions in the external fat on almost all beef table cuts and reductions in seam fat for chuck and round cuts. However, improvements in quality require transmission of price signals from the retail level to cattle feeders. These signals have not been apparent and pricing institutions have been slow to adjust, even though the grading system for carcass yield provides an appropriate measure of quality. This market failure could provide incentive for further vertical integration in the cattle industry. If so, the beef industry would become part of a larger agribusiness trend towards greater vertical integration in order to control quality and differentiate products (Streeter, Sonka, and Hudson).

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Notes

[1] The six cities surveyed in October/November 1987 were Denver, Seattle, Houston, New York, Tampa, and Chicago. The six surveyed in February/March 1988 were Dallas, Los Angeles, Detroit, Philadelphia, Atlanta, and Washington, DC.

[2] There is also the issue of whether we are identifying supply or demand in these data. Rosen demonstrated that any estimated hedonic price represents both the marginal utility of characteristics to consumers (demand) and the marginal cost of producing goods with a certain characteristic (supply). Rosen suggested that the demand curve is identified when all consumers are identical but producers have different costs of production. Hanneman further suggests that the identification problem is the same as that which arises in the neoclassical model, and that if the consumer faces perfectly inelastic supply curves for commodities, there is no identification problem. Beef quantities supplied (and hence beef characteristics) are predetermined at the retail level for short time periods. Therefore, these estimated hedonic prices identify consumer demand for quality characteristics.

[3] Six of the cities were sampled in the first time period and six in the second time period. Therefore, it was necessary to exclude one city dummy from each time period to avoid creating a singular data matrix. As Dallas and Houston are the two closest cities in the sample and each was surveyed during a different time period, these two were chosen for exclusion.

[4] The estimated model in equation (2) requires the assumption that marginal implicit prices are constant. This assumption may not hold for very large changes in characteristics; the marginal value of fat reduction is likely to decline at some point.

[5] A further complication is that producers are currently rewarded for producing carcasses with the quality grade "Choice," which requires marbling. (Quality grades are distinct from yield grades.) For any animal, time on feed increases backfat (reducing cutability) and marbling (improving quality grade). Thus producers must trade off any premium received for better cutability against the premium received for higher quality grade.

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Appendix

Table A1. Regression Results and Corrected Standard Errors

	Chuck Roasts		Chuck Steaks		Round Roasts	
	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error
Intercept	289.68	10.20	260.66	11.72	312.30	16.05
Bone-in	−42.52	4.48	−75.93	7.33	4.44	13.29
Time	−.22	20.68	6.19	13.27	−41.64	19.88
Tampa	−6.21	19.68	22.69	11.04	12.44	18.42
Denver	−29.39	20.12	13.58	9.71	37.74	16.84
Chicago	−79.38	20.78	67.40	29.26	14.11	15.32
Seattle	−42.04	21.10	−5.05	14.18	33.24	20.56
New York	1.77	21.55	44.33	10.05	3.21	16.56
Philadelphia	−21.26	10.50	35.89	12.61	25.51	14.98
Atlanta	−14.38	9.30	12.90	10.40	−11.58	20.04
Washington, DC	50.28	8.71	78.72	11.23	−33.61	15.49
Detroit	−40.67	10.81	−5.94	10.33	11.05	19.74
Los Angeles	−35.62	13.37	23.68	15.93	23.13	15.25
Fat Thickness	−.91	.23	−.46	.25	−1.19	.38
Marbling	−4.11	1.22	−1.43	1.17	−1.98	1.68
Seam Fat	−2.59	.75	−2.48	.96	−7.51	2.02
Adjusted R^2	.56		.54		.23	
White's Test	401.14		1,178.70		279.51	
Highest Condition Index	14.01		16.86		13.45	

Appendix

Table A1. Continued

Round Steaks		Rib Steaks		Loin Steaks		Sirloin		Miscellaneous	
Parameter Estimate	Standard Error	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error
287.93	9.71	602.57	16.17	600.45	21.73	403.76	14.43	329.31	11.24
−9.76	7.94	−110.76	8.70	−90.80	7.44	−29.94	7.09	−141.61	7.96
50.40	11.86	−31.10	24.00	−6.87	18.98	29.62	28.08	−9.77	12.21
−13.52	10.98	−35.19	21.66	−89.56	17.10	−43.69	22.81	17.61	13.86
−17.70	11.30	−46.07	22.54	−50.21	21.73	−31.48	26.35	−21.99	12.92
−21.96	11.38	−94.50	26.27	−29.50	21.52	−42.47	30.73	23.80	14.12
−24.32	10.96	−88.85	24.30	−17.85	17.74	.21	23.44	26.90	19.41
−17.60	10.96	−41.58	24.37	−65.91	19.45	−44.89	28.95	12.77	10.32
61.64	8.17	−139.34	16.01	−173.17	15.76	−172.38	10.49	−2.03	12.02
20.27	8.96	−89.23	15.58	−96.97	24.73	−94.11	12.74	−1.80	13.54
9.24	7.95	−56.51	17.94	72.07	16.18	118.08	15.31	33.57	14.09
21.44	11.00	−53.10	20.84	−51.16	15.77	17.48	19.39	10.71	21.53
39.97	9.77	−121.96	19.96	−87.50	23.42	−45.38	23.52	13.53	13.60
−1.22	.19	−1.76	.53	−2.26	.55	−1.47	.72	−2.29	.29
2.43	1.36	−.20	2.34	5.53	2.94	−.70	2.46	−.05	1.01
−6.02	1.34	.97	.98	3.79	2.61	2.61	2.75	−.62	.76
.23		.50		.52		.62		.41	
212.76		1,033.92		344.16		958.22		254.52	
11.82		18.86		16.84		15.13		10.07	