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Consumer Perception of Fat and Demand for Beef in the United States

The relationship between beef demand and its fat content is analyzed using the 1987-88 Nationwide Food Consumption Survey. The results show that beef demand is inelastic to meat expenditure and its own price. The magnitude of the own price elasticity is smaller than the fat elasticity of beef price. Socio-demographic variables are determinants of consumer perception of fat in beef. These findings provide economic support of producing and marketing leaner beef.

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From 1971 to 1989 per capita red meat consumption declined from 72 kg to 61 kg (CAST, 1991). This is partially attributed to consumer health concerns (Gao & Shonkwiler, 1993). According to the CAST (1991), consumers would purchase more beef if the fat was well trimmed for retail display. In addition, consumers will expect meat products in the 1990s to be leaner, more convenient to prepare, and perceived to be healthful. Based on these consumer views, an economic analysis on the relationship between consumer perception of fat and demand for beef is particularly timely.

In the past several decades, the demand for meat has been extensively studied by economists (Tomek, 1965; Chang, 1977; Moschini & Meilke, 1989; etc.). Since the relationship between undesirable nutrients such as fat and cholesterol in the American diet and public health has been well recognized, many economists such as Brown and Schrader (1990) and Capps and Schmitz (1991) have started incorporating consumer health concern and nutrition into food demand analysis. They all found consumer health and nutrition concerns have a significant effect on food demand. However, they only incorporated a cholesterol information index in their demand models. How consumer perceived and concerned the undesirable nutrients such as fat and cholesterol in food were overlooked. Recently, Unnevehr and Bard (1993) reported that consumers are willing to pay more for removing fat from beef. Unfortunately, they did not investigate the impact of consumer perception of fat on beef demand.

This study focuses on the trimming of excess fat (external and internal fats are not distinct in this study) from beef by examining the relationship between consumer perception of fat and demand for beef using the 1987-88 Nationwide Food Consumption Survey. Beef is postulated to be available in a variety of qualities in marketplaces. Consumers make decisions on how much to purchase as well as at what qualities. The effect of quality characteristics in durable goods such as automobiles and computers as well as nondurable goods such as food on consumer behavior has long been recognized (e.g., Waugh, 1928; Houthakker, 1952; and Griliches, 1971). However, research on incorporating quality variation into applied demand analysis is lacking. This research addresses this shortcoming. Specifically, the purpose of this study is two-fold. One is to analyze consumer evaluation of fat in beef, and the second is to address the impact of fat content on beef demand.

Model Specification

In marketplaces, different qualities (grades) of foods are available to consumers and are priced accordingly. Beef, for example, may be graded from fat beef (low quality) to lean beef (high quality) according to its fat content. Based on their budget constraints, consumers have different preferences for different qualities of beef. Because marginal utility of income is a decreasing function of income (Tweeten & Mlay, 1986),low income consumers may overestimate the value of low quality beef while high income consumers overestimate the value of high quality beef. There is an optimal fat content level at which both low and high income consumers have the same quality valuation. Any other fat content level represents a loss to consumers since there is some discrepancy between the consumer valuations and the true quality valuation. The optimal fat content for producers is the point at which the marginal gain equals marginal loss from the fat reduction.

The changes of producer and consumer well-being from the fat reduction are determined by the shift and slope of the supply and demand curves. Therefore, the decision of fat trimming in the beef industry depends on consumers' perception of fat and the magnitude of willingness to pay for fat reduction beside the production cost of trimming fat. The consumer perception of fat and willingness to pay for fat reduction can be measured by own price elasticity and fat elasticity of price. These parameters can be estimated from the following economic model.

Following the approach used by Capps and Schmitz (1991), the consumer utility function can be expressed as:

$$U = U(q(Z(r))) , \quad (1)$$

where r is a vector of commodity attributes which a consumer identifies as qualities, q is a commodity vector which the consumer perceives with quality r, and Z represents how consumers perceive the quality attributes. The Marshallian demand function for good i derived from the above utility specification can be expressed as:

$$q_i = q(y, p(r)) , \quad (2)$$

where y is consumer budget and p is a price vector which associates the consumer's perception of the commodity quality. The equation implies that both demand and price are choice variables to consumers. Thus, consumer perception of fat and demand for beef can be specified.

Since consumers are willing to pay for removing fat from beef (Unnevehr & Bard, 1993), beef should be priced according to its fat content, other things equal. Therefore, demand for beef is determined by total meat expenditure, beef price which is affected by its attributes such as fat content, prices of other meat and related products, and socio-demographic variables. The demographic variables capture the effects of other quality factors or consumer beliefs on beef demand because prices and expenditure seem inadequate in explaining observed patterns of meat consumption (Chalfant & Alston, 1988). These variables such as family size and race have traditionally played a major role in the analysis of household demand behavior (Pollak & Wale, 1992, p.11). The empirical functional form is specified as a constant elasticity demand model:

$$\ln(Q_{bf}) = \alpha_0 + \alpha_1 \ln(EXP) + \alpha_2 \ln(P_{bf}(r_{bf})) + \sum_{i=1}^{n} \alpha_{i,2} \ln(P_i) + \sum_{j=1}^{m} \alpha_{n+j,2} D_j + u , \quad (3)$$

where Q_{bf} and P_{bf} are quantity and price of beef, respectively, EXP is meat expenditure, P_i is price of other meat i (i.e., pork, lunch meat, poultry, and fish),[5] D is a set of demographic variables, α's are parameters to be estimated, and u is the error term. This functional form is chosen because of its linearity in parameters, robust to model mispecification, and appearance of elasticities as parameters (LaFrance, 1986).

The vector D in the demand function includes household size, educational level and race of household head, and region of resident. The household size is used to capture the effect of economy of size. The educational level and race represent consumer characteristics which affect consumer choice on specific beef items. For example, consumers at different educational levels may purchase beef at different qualities. The region of resident capture the regional differences in consumption traditions.

Based on the procedure used by Houthakker(1952), Deaton(1988), and the hedonic methodology, the beef price is assumed to be determined by the fat content of beef, and consumer economic and socio-demographic characteristics. The empirical specification is expressed as:

$$\ln(P_{bf}(r_{bf})) = \beta_0 + \beta_1 \ln(FAT) + \beta_2 \ln(FC) + \sum_{j=1}^{d} \beta_{2,j} D_j + e , \quad (4)$$

where FAT is fat content of beef, FC is total food cost, D is a vector of consumer demographic variables, ß's are parameters to be estimated, and e is the error term.

The β_1 is interpreted as the fat elasticity of beef price and is expected to be negative representing consumers' willingness to pay for fat reduction. In addition, this parameter is important in determining optimal fat trimming schemes. Compared with the α_2 parameter in the beef demand function, own price elasticity of beef, a larger β_1 in absolute value implies that the beef industry may enhance revenue by marketing leaner beef. Demographic variables are used to capture consumer perception on beef quality.

Total food cost (FC) (including at- and away-from-home food expenditure) rather than total meat expenditure, EXP in equation (1), is used to capture consumer perception in quality. The FC is used as a proxy of consumer income based on the belief that beef quality is related to FC more directly than to income. A positive β_2 is plausible so that high income consumers purchase more expensive (high quality) beef items. A

quality elasticity of beef can be defined as (Houthakker, 1952):

$$E_q = \frac{P_{bf}}{FC}\frac{\partial P_{bf}}{\partial FC} = \beta_2 . \qquad (5)$$

Equations (1) and (2) comprise a recursive simultaneous equation system and can be estimated by two-stage least squares (2SLS) procedure.

Data

Data used in this study are from the 1987-88 Nationwide Food Consumption Survey (NFCS) which was conducted between April 1987 and August 1988 sponsored by the United States Department of Agriculture. The survey contains food consumption and socio-economic and demographic information on 4,273 housekeeping households[6] in the 48 conterminous states in the United States. Among those, 3,603 households who consumed beef during the survey week are used for the analysis. Five meats (i.e., beef, pork, lunch meat, poultry, and fish) are defined as the consumption bundle due to expected cross substitutional and complimentary relationships. Lunch meat includes hot dogs, frankfurters, and other lunch meats except boiled ham and roast beef.

The selected socio-demographic variables are standard household size, educational level and race of household head, food stamp participation, region and urbanization of resident, and household head status. Definitions of these and selected continuous variables (meat expenditure, total food cost, fat content of beef, beef consumption, and prices of the five meats) and their selected sample statistics are presented in table 1.

Treatment of Missing Prices

During the survey week, not all the 3,603 households consumed all five meats. Some prices are unobserved for some households who did not consume a meat during the survey week. In addressing this issue, there are several approaches proposed in the literature. One approach is to approximate the missing prices by an inverse semi-log specification. The inverse semi-log is used to avoid negative predicted prices. The missing prices are predicted by regressing the logged available prices on other available independent variables. One caveat of this approach is the introduction of random factors into the demand model. Additionally, the model for predicting missing prices is likely to be incorrect (Pudney, 1989)

Two simpler and most commonly used ways are discarding the observations which have missing prices or replacing the missing prices with "appropriate" sample means. It is often arbitrary to select which method to be used. In this study, there are only 813 households which consumed all five meats during the survey period. Severe sample bias may occur if the observations which have missing prices are discarded. Therefore, the missing. prices are replaced by regional means in this study. The regional means are calculated based on the region and urbanization area of residents and educational level of household head.

The region and urbanization area of residents are used for computing the sample means because they may reflect the price differences due to marketing situations and regional consumption traditions. Theeducational level of household head determine which store consumers are more likely to purchase from. Different stores may charge different prices for a meat because of quality differences, shopping environment, and other services such as packaging, cleaning, and cutting.

Results and Discussion

The beef demand and price equations were estimated by two-stage least squares (2SLS) method. The results are statistically plausible (Table 2). For the beef demand equation, thirteen out of 15 (86.7%) parameters are statistically significant at the 0.05 level. The R^2 is 0.40 which is acceptable for an analysis of cross-sectional data. Eleven out of 15 (73.3%) parameters in beef price equation are statistically significant at the 0.01 level. The price equation has a R^2 of 0.19. Cox and Wohlgenant (1986) used a similar specification for vegetable prices and reported the R^2's of 0.05, 0.03, and 0.04 for fresh, canned, and frozen vegetables, respectively. Regarding to their very low R^2s,they concluded that quality impact on price was small for vegetables and indicated that physical characteristics which reflect commodity qualities should be included. Results of this study suggests that fat in beef is an appropriate physical attribute which consumers identify as quality.

The estimated demand elasticities of beef with respect to expenditure and its own price are 0.79 and -0.33, respectively. This is consistent with the results of Capps and Schmitz (1991) who emphasized the importance of health and nutrition information on the demand for food. As early as 1960's, Tomek (1965) has pointed out that beef has become less price elastic and partially attributed this to quality changes in the product. The inelastic demand elasticity suggest that consumers

Table 1
Variable Definition and Selected Sample Statistics (N^a = 3,603)

Variables	Definition	Means
EXP($/wk)	Per capita expenditure on five meat commodities	8.27 (5.60)[b]
FC($/wk)	Per capita total food cost (at- and away-from home)	91.72 (561.29)
FAT(g)	Fat contents per pound of beef	88.18 (16.45)
Q_{bf}(lb/wk)	Per capita beef consumption	1.76 (1.40)
P_{bf}($/lb) (N=3,603)	Beef price defined as dividing expenditure by quantity	1.91 (0.85)
P_{pk}($/lb) (N=2,983)	Pork price defined as dividing expenditure by quantity	2.08 (0.87)
P_{lm}($/lb) (N=2,762)	Lunch meat price defined as dividing expenditure by quantity	2.11 (0.90)
P_{pt}($/lb) (N=3,118)	Poultry price defined as dividing expenditure by quantity	1.40 (1.05)
P_{fh}($/lb) (N=2,242)	Fish price defined as dividing expenditure by quantity	2.92 (1.74)
SFS	Standard family size (21 meal equivalent person)	2.56 (1.34)
ED1	1 if household head completed less than 9 years of school, 0 otherwise	0.133
ED3	1 if household head completed 1-4 years of college, 0 otherwise	0.307
ED4	1 if household head completed more than 4 years of college, 0 otherwise	0.068
RA1	1 if household head is white, 0 otherwise	0.851
RS	1 if household currently receive food stamps, 0 otherwise	0.075
FEM	1 if household headed by female only, 0 otherwise	0.228
NE	1 if northeast region resident, 0 otherwise	0.198
MW	1 if midwest region resident, 0 otherwise	0.273
SOUTH	1 if south region resident, 0 otherwise	0.347
URB1	1 if household lives in central city, 0 otherwise	0.221
URB3	1 if household lives in non-metro area, 0 otherwise.	0.301

[a] N denotes number of observations.
[b] Number in parenthesis is standard deviation.

Table 2
Estimation Results of Beef Demand and Price Equations by 2SLS

Variable	Demand Equation		Price Equation	
	Parameter estimate	Standard error	Parameter estimate	Standard error
Constant	-0.774**	0.062	2.607**	0.129
ln(EXP)	0.792**	0.022	---	---
$\ln(P_{bf})$	-0.328**	0.099	---	---
$\ln(P_{pk})$	-0.109**	0.036	---	---
$\ln(P_{lm})$	-0.105**	0.033	---	---
$\ln(P_{pt})$	-0.065**	0.020	---	---
$\ln(P_{fh})$	-0.075**	0.028	---	---
ln(SFS)	-0.060**	0.019	-0.044**	0.012
ED1	-0.003	0.032	-0.029	0.018
ED3	-0.112**	0.024	0.052**	0.013
ED4	-0.139**	0.043	0.101**	0.024
RA1	0.063*	0.030	0.053**	0.018
NE	-0.132**	0.033	0.068**	0.019
MW	0.066*	0.032	-0.093**	0.018
SOUTH	0.010	0.030	-0.024	0.017
ln(FC)	---	---	0.059**	0.008
ln(FAT)	---	---	-0.501**	0.027
FEM	---	---	-0.024	0.016
RS	---	---	-0.073**	0.023
URB1	---	---	0.015	0.015
URB3	---	---	-0.061**	0.014
R-Square	0.40		0.19	

** and * denote statistical significance at the 0.01 and 0.05 levels, respectively.

may be more interested in beef quality rather than quantity (Menkhaus *et al.*, 1993). The inelastic own price elasticity provides economic support of trimming fat from beef.

The estimated cross price elasticities show that all the meats are complements although they are very inelas ic respect to cross prices. A possible explanation is that quality variations of meat outweighs price effects for consumers in the 1990's (Wesenberg, 1990). If an individual consumes low quality beef such as not-well-trimmed and bone-in beef, he/she is also more likely to consume low quality pork. If the low quality commodities are represented by large quantities for reasons such as not-well-trimmed and bone-in meat, the complements relationship may present. Moreover, consumers may switch away from meat to other foods such as vegetables and fruits due to their growing health concerns. This offers another possibility of presenting complementary relationship between meats. This finding appears in conflict with those of previous studies. Capps and Schmitz (1991) and Spreen and Gao (1993) found meat and related products as very inelastic to cross prices with a majority of the commodities as substitutes. This may be due to that Capps and Schmitz used time series data (1966-88) while Spreen and Gao used more disaggregated data such as steak and roast.

Per capita demand for beef declines as household size increases. This indicates that large households may consume more variety of meats owing to possible taste differences. The estimated coefficients of educational levels indicate that consumers with more years of education consume less beef than consumers with few years of education. White households tend to demand more beef than do the other races. Compared with consumers in the west region, the northeast consumers demand less while midwest consumers demand more beef. Demand for beef is not significantly different between consumers in the west and south regions.

The coefficient for food cost in the price equation is statistically significant and positive as expected. The positive estimate indicates that high income consumers demand high quality products. This is consistent with the findings of previous studies. Black (1952) concluded that high income consumers paid higher prices for food than low income consumers. Cox and Wohlgenant (1986) found high income consumers pay higher price for fresh vegetables than low income consumers using the 1977-78 NFCS. Consistent with Unnevehr and Bard (1993), the elasticity of price with respect to fat content is statistically significant and negative (-0.501). This implies that fat is negatively valued. Consumers are willing to pay more for reducing fat content in beef. This elasticity is larger than the own price elasticity of beef (-0.328) in absolute value although both elasticities are less than unity. This relationship implies that trimming extra fat may improve the net revenue of the beef industry.

Economy of size is present as shown by the significant and negative coefficient of standard household size. Similar results were found by Cox and Wohlgenant (1986). They reported that large households pay low prices for fresh, canned, and frozen vegetables. The estimated parameters for educational levels indicate that consumers with more years of schooling pay a higher price for beef than consumers with few years of schooling. Cox and Wohlgenant reported that consumers who have completed college demand higher quality of canned vegetables than do the less educated consumers. A comparison of the parameters with their associated parameters in the demand equation indicates highly educated consumers substitute quantity for quality.

White households pay a higher price for a unit of beef than other races. Similarly, Cox and Wohlgenant found nonblack households pay higher price for fresh and canned vegetables. In addition, white households also demand more beef than do the other races as shown by the significant parameter in the demand equation. This finding has important implication to the beef industry. Because consumers demand more high quality beef, producing and/or marketing leaner beef may enhance the profit of the beef industry. Compared with the west region households, households pay more in the northeast and less in the midwest regions for a unit of beef. This explains why consumers demand less beef in the northeast and more beef in the midwest regions as seen in the demand equation.

The parameter for the food stamp variable is statistically significant and negative. This implies that the food stamp recipients consume lower quality beef than do the other households. The results also indicate that beef quality is lower for households living in non-metro area than those living in other areas.

Conclusion

The relationship between consumer perception of fat and demand for beef is specified in an economic model. The model is applied to a cross-sectional data from the 1987-88 Nationwide Food Consumption Survey. Consisting with previous studies such as Capps and Schmitz (1991), the results indicate that beef demand is rather inelastic to meat expenditure and its own price. These inelastic elasticities and the estimated coefficients of the demographic variables suggest that consumers substitute quantity for quality. This finding is important for beef production and marketing. For example, producing and marketing leaner (high quality) beef may be a key avenue for the beef industry to enhance profit. The finding of the complementary relationship among meats is quite different from the general assumptions and the results of previous studies. This may raise a challenge for conducting cross-sectional demand analyses and understanding consumer food consumption behavior.

The fat elasticity of beef price suggests that consumers are willing to pay a higher price for reducing fat content in beef. Furthermore, the fat elasticity is larger than the own price elasticity of beef demand in absolute magnitude. Thus, the beef industry could potentially achieve a higher profit if more fat is trimmed. Per capita total food cost, family size, region and urbanization of resident, food stamp participant, educational level and race of household head are major determinants of consumer perception of fat in beef. These results are useful for initiating appropriate marketing strategies such as marketing segmentation. For example, more fat should be trimmed in the northeast region and the regions and/or areas with more highly educated consumers residing.

References

Black, G. (1952). Variations in prices paid for food as affected by income level. Journal of Farm Economics, 34(1), 52-56.

Brown, D.J. & Schrader, L.F. (1990). Cholesterol information and shell egg consumption. American Journal of Agricultural Economics, 72, 548-555.

Capps, O., Jr. & Schmitz, J.D. (1991). A recognition of health and nutrition factors in food demand analysis. Western Journal of Agricultural Economics, 16, 21-35.

Cast: Council for Agricultural Science and Technology (1991). Food fats and health. Task Force Report No. 118.

Chalfant, J.A. & Alston, J.M. (1988). Accounting for changes in tastes. Journal of Political Economy, 96,391-410.

Chang, H.S. (1977). Functional forms and the demand for meat in the United States. The Review of Economics and Statistics, LIX, 355-359.

Cox, T.L. & Wohlgenant, M.K. (1986). Prices and quality effects in cross-sectional demand analysis. American Journal of Agricultural Economics, 68, 908-919.

Deaton, A. (1988). Quality, quantity, and spatial variation of price. The American Economic Review, 78, 418-430.

Gao, X.M. and Shonkwiler, J.S. (1993). Characterizing taste change in a model of U.S. meat demand: correcting for spurious regression and measurement errors. Review of Agricultural Economics, 15, 313-324.

Griliches, Z. (1971). Chapter 1 & 3, In Griliches (Ed.), Price Indexes and Quality Changes. Cambridge, MA: Harvard University Press.

Houthakker, H.S. (1952). Compensated changes in quantities and qualities consumed. Review of Economic Studies, 19, 155-164.

LaFrance, J.T. (1986). The structure of constant elasticity demand models. American Journal of Agricultural Economics, 68, 544-552.

Menkhaus, D.J., Colin, D.P.M., Whipple, C.D. & Field, R.A. (1993). The effects of perceived product attributes on the perception of beef. Agribusiness: An International Journal, 9, 57-63.

Moschini, G. & Meilke, K.D. (1989). Modeling the pattern of structural change in US meat demand. American Journal of Agricultural Economics, 71, 253-261.

Pollak, R.A. & Wales, T.J. (1992). Demand System Specification and Estimation. New York: Oxford University Press, Inc.

Pudney, S. (1989). Modeling Individual Choice: The Econometrics of Corners, Kinks and Holes. New York: Basil Blackwell Inc.

Speen T. & Gao, X.M. (1993). Health concerns and convenience and the structure of U.S. meat demand. Paper presented at the Annual Meeting of the American Agricultural Economics Association, Orlando, FL, August 1-4.

Tomek, W.G. (1965). Changes in price elasticities of demand for beef, pork, and broilers. Journal of Farm Economics, 47, 793-802.

Tweeten, L. & Mlay, G. (1986). Marginal utility of income estimated and applied to problems in agriculture. Agricultural Policy Analysis Background Paper B-21. Stillwater, OK: Dept. of Ag. Economics, Oklahoma State University.

Unnevehr, L.J. & Bard, S. (1993). Beef quality: will consumers pay for less fat? Journal of Agricultural and Resource Economics, 18, 288-295.

Waugh, F.V. (1928). Quality factors influencing vegetable prices. Journal of Farm Economics, 10, 185-196.

Wensenberg, D.C. (1990). The changing consumer environment of retail store food service. Journal of Food Distribution Research, 21, 59-62.

Endnotes

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5. Other prices are not assumed to be a function of quality due to data limitations and requirement of assumptions in economic modelling.
6. The housekeeping household is defined as at least one member having ten or more meals from household food supply during survey week.