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# Effects of Health Concerns and Consumer Characteristics on U.S. Meat Consumption

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There have been substantial shift in U.S. meat consumption trend from red to white meat over the last three decades. Considerable researches have been conducted to detect potential changes in the underlying meat demand structures (Chavas, 1983; Thurman, 1987; Chalfant and Alston, 1989; Eales and Unnevehr, 1993; Choi and Kim, 1993). Majority of the studies found significant structural changes in the preferences for meat demand, indicating that nature of the shift is not reversible short-run fluctuations due to market conditions. Increased health concerns were often hypothesized as a fundamental force driving the change in meat market shares.

Several studies have examined the empirical linkage between meat consumption and health issues using aggregate time-series disappearance data and the health information index developed by Brown and Schrader (1990). Kinnucan et al. (1997) examined the effects of health information on beef, pork, poultry, and fish. Health information had a negative effect on beef and a positive influence on poultry and fish. Capps and Schmits (1991) found no significant effect of the same health index on beef while showing statistically significant and negative impact on pork. Using a slightly different index (CHOL), McGuirk et al. (1995) reported an intriguing result that pork consumption was positively associated with health information.

Brown and Schrader (B&S) index was constructed using the number of medical journal publications dealing with the linkages between cholesterol and heart diseases over the period of 1957-1987. While B&S index was a major breakthrough in measuring a noneconomic preference variable and incorporating it into food demand analysis, it did not directly measure consumer attitudes or knowledge about health issues. Furthermore, the three studies using B&S and CHOL indices revealed considerable inconsistencies in the effects of health information on different meat products.

Considering the significance of understanding the underlying causes of changes in meat demand for livestock, processing and retail industries, it must be worthwhile to search for an alternative and direct way of measuring consumer attitudes or knowledge about health issues. In this article, we develop an index of consumer attitudes about fats and cholesterol intake using survey data collected cross-sectionally and over time by NPD (National Panel Diary) group, and evaluate the effects of the index on beef, pork, chicken, turkey, and fish consumption at the disaggregated household level. NPD data also provide detailed information about consumer demographics including those of female head in the households. Accordingly, in addition to health concerns, we examine how meat consumption patterns differ across household and consumer characteristics.

**Conceptual Framework for Preference Analysis**

To motivate a discussion of the theoretical model linking health concerns and meat consumption, we depend on the model of variable preference developed by Bassman (1955). The model is represented with the following utility function for an individual ***i***,

(1) $$u_i = u_i(X_i, Z_i; q_i(r, D))$$

where **X** is a vector denoting the quantities of meat products; **Z** is a composite good other than meat; and $\theta_i$ is a parameter vector defining the shape of the ordinal utility function. Bassman assumes that $\theta_i$ depends on (***r***), a vector of variables such as advertising expenditures. We added a vector (***D***) representing socioeconomic and demographic characteristics that can have a direct effect on the shape of the utility function.

Capps et al. (1991), in order to formally introduce health and nutrition factors in food demand analysis, redefined (***r***) as types of state variables such as stock of knowledge or psychological stock of habits. In this article, we define (***r***) as health concerns about the intake of fats and cholesterol. Health concerns are expected to be a direct function of scientific information with regard to the linkage between chronic diseases and dietary choices. In this model, changes in health concerns or scientific information are hypothesized to lead to changes in the parameters of the utility function, which in turn gives rise to changes in the commodity vectors, **X** and **Z**. Hence, the parameters of utility functions are dependent on particular psychological variables to account for changes in tastes and preferences. Maximization of equation (1) with respect to **X**, given (***r*** ) and (***D***) yields a Marshallian demand function of the form,

$$(2) \qquad X_i = X_i(y_i, p; q_i(r, D_i))$$

The resulting demand equation indicates that consumer demand relationship depends not only on prices and income but also a vector of state variables and socioeconomic and demographic characteristics.

**NPD Data and Empirical Model Specification**

The NPD group is a private corporation that collects and sells household diary data on consumer attitudes, demographics, and consumption practices. The NPD database include households reporting the number of servings of each meat product included in a period of two weeks. These serving numbers are divided by the number of members in the household, thus giving a measure of meat product use expressed in servings per household member. Thus, the number of servings represents a continuous variable having a minimum of zero and no measurable maximum. The full database includes monthly information covering the period from 1984 through 1997. These months, along with the reporting households, give a total of 26,440 observations.

In addition to meat consumption activities, each household's primary food provider responds to questions about health, attitudes, behavior, and demographics. Some questions require a scaled response, usually in terms of Likert scale of agreement or concern. For example, the question can be "one should be cautious about the intake of fat". Then, the respondents provide ordinal response using six point agreement scales ranging from 'completely agree' to 'mostly disagree'. Other questions may be in terms of degree of encouragement or discourage.

Health concern index is derived from the degree of concern households have about fats and cholesterol. Expressed concerns of consumers about those two variables were found to be highly interrelated, indicating that consumers who express concern for fats are more likely to express concern for cholesterol. Statistically, such correlations can cause multicollinearity problems in econometric estimation procedures. Hence, using principal component procedures, we create an index variable representative of the information found within the group (Chatterjee and Price 1977; Dunteman, 1989). The first principal component, defined to be HC1, explained about 90 percent of the total variation in the group, and we use it as an index of health concerns in empirical meat demand models.[1]

There is a group of attitudinal variables representing households' fast food eating behavior that can provide insights about the linkage between eating habit and meat consumption. The group of attitudinal variables addresses the eating of fast foods such as pizza, fried chicken, luncheonmeat, french fries, and tacos. Since the five data series are highly correlated, ranging from 0.65 to 0.84, similar procedures as in the development of health concern index are used to derive independent information from the original data. The first two principal components(BH1 and BH2) which explain about 85 percent of the total variation, are included in the empirical analysis.

The NPD data include an array of socioeconomic and demographic variables including characteristics of female head that can have direct impacts on meat consumption. Specifically, household income, market size, age, education and employment status of female head, and geographic regions are considered in this article. Household income was recorded originally with nine categories and simplified into four categories, entering the empirical model as binary variables. The first category was omitted from the model and used as a base. Data were collected from nine geographical regions across the nation and aggregated into four regions: Northeast, Central, South, and West. The northeast region was used as a base in the empirical model. Table 1 presents descriptions and

[1]Before calculating principal components, the variables were standardized to remove scale differences across variables.

summary statistics of attitudinal data and sociodemographic profiles used in the empirical model specification.

**Generalized Heckman's Model**

The reports of household servings of each meat category contain significant proportion of zero consumption. For example, while approximately 17 percent of the households did not consume any beef in a two-week period, nearly 50 percent reported zero servings of turkey during the same time period. Omitting those zeros in ordinary least squares estimation will results in inconsistent estimates from selectivity bias and also considerable loss of information contained in the zero observations. Zero servings occur due to responses to changing economic conditions or to nonpreference. Hence, in addition to consumption decision equation, it is important to have a separate equation modeling the decision process that produces zero (Maddala, 1993). Cragg's double-hurdle model and Heckman's sample selection model provide useful two-step decision making frameworks (Cragg, 1971; Heckman, 1979; Jones, 1989).

Since this study deals with five commodities potentially related through error structures, the servings equations for each commodity need to be estimated simultaneously so as to gain efficiency. While double-hurdle models are not rendered for joint estimation, Heckman's model can be generalized to incorporate multiple-equation models (Amemiya, 1974; Lee, 1978; Heien and Wessells, 1989; Park et.al., 1996; Nayga, 1994; Byrne, 1996). Estimation of generalized Heckman's model involves two steps. Let $y_{i(ht)}$ be the number of servings of each meat with the subscripts ($h$) and ($t$) denoting household and time period, respectively; $D_{i(ht)}$ be dichotomous variable equal to one if $y_{i(ht)}$ is greater than zero and equal to zero otherwise. Subscript ($i$) denotes beef, pork, chicken, turkey and fish. Then, the first-stage probit model determining the probability of consuming each meat category is defined as,

(1) $$P[D_{i(ht)} = 1] = F(X_{ht}\theta) = 1 - F(-X_{ht}\theta)$$

$$P[D_{i(ht)} = 0] = F(-X_{ht}\theta) = 1 - F(X_{ht}\theta)$$

where $X_{ht}$ is a vector of explanatory variables delineated in the preceding section, $\theta$ is a vector of unknown parameters, and $F(X_{jt}\theta)$ is a standard normal cumulative distribution function. Using consistent estimates of the probit models, inverse mills ratios for the households participating in meat market and for those reporting zero consumption are defined by,

(3) $$mills_{i(ht)} = f(X_{ht}\hat{\theta})/F(X_{ht}\hat{\theta}),\ for\ D_{i(ht)} = 1$$

(4) $$mills_{i(ht)} = f(X_{ht}\hat{\theta})/[1 - F(X_{ht}\hat{\theta})],\ for\ D_{i(ht)} = 0$$

where $f(X_{ht}\hat{\theta})$ is a standard normal density function. Assume that the second-stage servings equation is specified as a linear function of explanatory variables; $y_{i(ht)} = X_{ht}\beta_i + e_{i(ht)}$. Then, given the dichotomous variable $D_{i(ht)}$, conditional means of the servings equation can be written as,

(5) $$E[Y_{i(ht)}|D_{i(ht)} = 1] = X_{ht}\beta_i + \eta_i \frac{f(X_{ht}\hat{\theta}_i)}{F(X_{ht}\hat{\theta}_i)}$$

(6) $$E[Y_{i(ht)}|D_{i(ht)} = 0] = X_{ht}\beta_i + \eta_i \frac{f(X_{ht}\hat{\theta}_i)}{1 - F(X_{ht}\hat{\theta}_i)}$$

Given the expressions for inverse mills ratio for zeros and positives, the system of regression equations correcting for potential selectivity bias can be written in matrix notation,

(7) $$\mathbf{Y}_i = \left[\mathbf{X}_i\ \ \mathbf{M}_i\right]\left[b_i\ \ h_i\right]' + \mathbf{e_i}$$

where $\mathbf{M_i}$ denotes a vector of inverse mills ratios for each meat product.

**Marginal Effects in a System of Equations**

In equation (7), parameter vector $\beta_i$ does not represent marginal effects because of the presence of inverse mills ratios. Explanatory variables directly impact the number of meat servings but also indirectly influence by changing the probability of becoming consumer of each meat category through the inverse mills ratios. Hence, secondary effects *via* inverse mills ratios should be taken into account in calculating full marginal effects in the generalized Heckman's model. Saha et.al (1997) suggests a way of calculating full marginal effects. Since both zero and positive servings are considered in the second-stage, marginal effect(ME) of $x_k$, evaluated at sample means, consists of two components,

$$(8) \qquad M\hat{E}_{ik}^{A} = \frac{\partial E[Y_i | D_i = 1]}{\partial x_k} = \hat{\beta}_{ik} - \eta_i \hat{\theta}_{ik} [\bar{X}\, \hat{\theta}_i \hat{\lambda}_i^A + (\hat{\lambda}_i^A)^2]$$

$$(9) \qquad M\hat{E}_{ik}^{B} = \frac{\partial E[Y_i | D_i = 0]}{\partial x_k} = \hat{\beta}_{ik} - \eta_i \hat{\theta}_{ik} [\bar{X}\, \hat{\theta}_i \hat{\lambda}_i^B - (\hat{\lambda}_i^B)^2]$$

where $\hat{\lambda}_i^A = f(\bar{X}_{ht}\hat{\theta}) / F(\bar{X}_{ht}\hat{\theta})$ and $\hat{\lambda}_i^B = f(\bar{X}_{ht}\hat{\theta}) / [1 - F(\bar{X}_{ht}\hat{\theta})]$. Note that subscripts identifying household ($h$) and time ($t$) have been dropped for convenience. To compute the overall marginal effects of explanatory variables, they proposed weighted average of equations (6) an (7),

$$(10) \qquad M\hat{E}_{ik} = \hat{\beta}_{ik} - \eta_i \hat{\theta}_{ik} \Big[ \delta \Big( \eta_i \hat{\theta}_{ik} [\bar{X}\, \hat{\theta}_i \hat{\lambda}_i^A + (\hat{\lambda}_i^A)^2] \Big) + (1 - \delta) \Big( \eta_i \hat{\theta}_{ik} [\bar{X}\, \hat{\theta}_i \hat{\lambda}_i^B - (\hat{\lambda}_i^B)^2] \Big) \Big]$$

where the weight, $0<\delta<1$, is the proportion of observations for which D =1.

**Empirical Results**

Parameter estimates from equation (7) are obtained by iterative seemingly unrelated regression method (ITSUR). Parameter estimates are reported in Table 2 along with other summary statistics. Parameter estimates associated with inverse mills ratios in each equation were all statistically significant, suggesting that failure to account for the zero observations would have resulted in sample selection bias in all of the five equations. R-squares measuring goodness-of-fit for the models were ranging from 0.297 to 0.531, exhibiting good fits for cross-sectional data.

Health concerns, noted with HC1, had negative and statistically significant effects on beef and pork, whereas having positive and statistically significant effects on chicken, turkey and fish. The more strongly the households were concerned about the intake of fats and cholesterol, the less frequently the households served beef and pork during a two-weeks period, while consuming chicken, turkey and fish more frequently. The findings indicate that white meat and fish industry have benefitted from health concerns about red meat. Overall, these results seem to yield cross-sectional evidences supporting the hypothesis that increased health concerns and consumer awareness about diet-disease linkages have been a major cause of the shift in meat demand patterns over the last three decades.

While coefficient of HC1 indicates a composite effect of the concern about fats and cholesterol, the effects of individual variables are yet to be determined. Coefficients of the original variables were recovered using the estimate of HC1 and loading factors of the principal component (Chatterjee and Price, 1977). Table 3 shows the recovered parameter estimates of fats and cholesterol for each meat and demonstrates that the directions of the effects of individual variables are consistent with the composite effect of health concern index.

To compare the relative responsiveness of each meat consumption to the health concern variables, we computed marginal effects based on equation (10), then elasticities for health concern variables at their sample means. Although computed marginal effects differed from the parameter estimates in magnitudes, the direction of impacts remained unchanged. Health concern elasticities for five meat categories are reported in table 4. While the range is generally inelastic, turkey and fish consumption shows relatively stronger response to health concerns as compared to other meats. Fats elasticity of 0.308 for beef translates into nearly one less serving per household member in a two-weeks period when consumer's degree of concern about fats changes from "mostly not concerned" to "strongly concerned".

As set forth in table 1, eating attitudes indexes(BH1 and BH2) are composed of fried chicken, taco, luncheon meat, hotdog, and pizza. Statistically significant and positive signs in the beef and pork equations suggest that the stronger the households encourage eating those fast foods, the households are likely to consume beef more frequently. In other words, the number of servings of beef and pork is positively associated with the attitudes toward fast foods. Results also show that attitudes toward fast foods are negatively related with white meat and fish consumption. The findings are generally comparable with negative linkages of health concern with red meats and positive association with white meat and fish.

Meat consumption frequencies clearly differed across demographic characteristics. In particular, household size had statistically significant and positive influences on consumption frequency across the five meat products. Female head education was found to be negatively correlated with red meat and positively with white meat and fish. Employment status of female head had negative effects in all of the five equations, suggesting that households with employed female heads generally tend to serve meats and fish less frequently as compared to those with female heads unemployed. This result contrasts with McGuirk's finding that increased participation of women in the labor force tend to lower beef demand and raise the consumption of chicken. Interestingly, market size had statistically significant and negative impacts on the number of beef, pork and turkey servings, and positive impacts on chicken and fish consumption. Consequently, households living in larger cities are likely to eat chicken and fish more frequently than those in smaller cities. This result could be because of the greater availability of chicken in fast food establishments and growing number of restaurants and stores specializing in fish in larger cities. Also, rural areas are likely to have greater chances to preserve life styles where beef is a major part of family meals.

With respect to regional differences in meat consumption pattern, consumers living in the Central region ate more beef and pork during a two-week period, while consuming less turkey and fish than those in the Northeastern region. Households residing in the Southern region consumed pork more often than those in the Northeast and West regions. Respondents in the West region served beef and turkey more frequently but chicken and fish less frequently as compared to those in the Northeast region.

**Conclusions**

Using NPD data collected cross-sectionally and over time, this study specified an empirical meat demand model incorporating health concern and demographic variables. A generalized Heckman's two-step procedure was used to deal with the significant proportion of zeros in reported consumption frequency and potential contemporaneous correlations among error terms. The estimated model clearly establishes empirical linkages between health concerns and meat consumption. Effects of health concerns varied across five meat categories including beef, pork, chicken, turkey and fish. Beef and pork were negatively linked to health concerns, whereas chicken, turkey and fish were positively associated with health concerns. Furthermore, calculated elasticities showed that turkey and fish servings was most responsive to health concerns among the five meats.

Table 1. Description and Summary Statistics of Explanatory Variables Used in Empirical Model.

| Variable | Description | Sample Mean |
|---|---|---|
| **Health Concerns**[a] | | |
| Fats | One should be cautious about the intake of fats | 5.32 |
| Cholesterol | One should be cautious about the intake of cholesterol | 5.02 |
| **Eating Habits**[b] | | |
| Hotdog | Do you encourage the eating of Hotdog sandwitch? | 3.45 |
| Pizza | Do you encourage the eating of Pizza? | 5.43 |
| Lunchmeat | Do you encourage the eating of Lunchmeat? | 2.34 |
| Tacos | Do you encourage the eating of Tacos? | 3.45 |
| Fried Chicken | Do you encourage the eating of Fried Chicken? | 4.34 |
| **Demographics** | | |
| Income I | 1=under $10,000; 0=otherwise | 0.36 |
| Income II | 1=$10,000-19,000; 0=otherwise | 0.18 |
| Income III | 1=$20,000-49,999; 0=otherwise | 0.25 |
| Income IV | 1=$50,000 or higher; 0=otherwise | 0.18 |
| Market Size | 1=rural; 2=50-249; 3=250-499; 4=500-999; 5=1 mil. | 2.71 |
| Household Size | Actual number of household member | 2.31 |
| Education [c] | 1=no high; 2=high school; 3=some college; 4=college grad. | 2.83 |
| Age | 1=<35; 2=35/44; 3=45/54; 4=55/64; 5=65+ | 2.76 |
| Employment | 1=employed; 0=not employed | 0.51 |
| **Regions** [d] | | |
| Northeast | 1=Northeast; 0=otherwise | 0.214 |
| Central | 1=Central; 0=otherwise | 0.255 |
| South | 1=South; 0=otherwise | 0.342 |
| West | 1=West; 0=otherwise | 0.187 |

[a] 1=Disagree mostly; 2=Disagree somewhat; 3=Neither agree nor disagree; 4=Agree somewhat; 5=Agree mostly; 6=Agree.
[b] 1=Almost always discourage; 2=Sometimes discourage; 3=Neither; 4=Sometimes encourage; 5=Almost always encourage; 6=Always encourage.
[c] Demographics for female head.
[d] Northeast=New England and Mid Atlantic; Central=East North Central and West North Central; South=South Atlantic, East South Central and West South Central; West=Mountain and Pacific.
Source: NPD Group, 1998.

Table 2. ITSUR Parameter Estimates of Generalized Heckman's Model for U.S. Meat Consumption.

| | Beef | Pork | Chicken | Turkey | Fish |
|---|---|---|---|---|---|
| Constant | 1.727(13.68)$^{***}$ | 0.390(6.763)$^{***}$ | 1.596(20.85)$^{***}$ | 0.239(2.525)$^{**}$ | 0.611(11.61)$^{***}$ |
| HC1 | -0.160(10.49)$^{***}$ | -0.029(5.708)$^{***}$ | 0.114(11.14)$^{***}$ | 0.079(10.07)$^{***}$ | 0.069(11.46)$^{***}$ |
| BH1 | 0.070(4.086)$^{***}$ | 0.026(4.468)$^{***}$ | -0.083(8.150)$^{***}$ | -0.078(10.33)$^{***}$ | -0.053(9.324)$^{***}$ |
| BH2 | 0.055(3.497)$^{***}$ | 0.051(9.167)$^{***}$ | 0.011(1.169) | -0.045(7.428)$^{***}$ | -0.012(2.311)$^{**}$ |
| Income II | 0.042(0.885) | -0.005(0.279) | -0.213(6.663)$^{***}$ | 0.052(2.168)$^{**}$ | -0.004(0.238) |
| Income III | 0.067(1.413) | -0.006(0.387) | -0.241(7.548)$^{***}$ | 0.120(5.110)$^{***}$ | -0.004(0.256) |
| Income IV | -0.177(3.256)$^{***}$ | 0.009(0.513) | -0.182(5.138)$^{***}$ | 0.173(6.721)$^{***}$ | 0.033(1.688)$^{*}$ |
| Market Size | -0.158(16.69)$^{***}$ | -0.025(7.585)$^{***}$ | 0.043(6.563)$^{***}$ | -0.003(0.890) | 0.019(5.401)$^{***}$ |
| Household Size | 0.832(32.28)$^{***}$ | 0.138(16.44)$^{***}$ | 0.276(19.10)$^{***}$ | 0.058(6.084)$^{***}$ | 0.049(6.529)$^{***}$ |
| Education | -0.257(13.92)$^{***}$ | -0.076(11.74)$^{***}$ | 0.025(2.189)$^{**}$ | 0.035(4.738)$^{***}$ | 0.022(3.557)$^{***}$ |
| Age | 0.009(0.761) | 0.053(11.20)$^{***}$ | 0.027(3.257)$^{***}$ | 0.041(7.500)$^{***}$ | 0.053(10.95)$^{***}$ |
| Employment | -0.348(10.31)$^{***}$ | -0.045(3.996)$^{***}$ | -0.201(9.038)$^{***}$ | -0.061(4.088)$^{***}$ | -0.105(8.590)$^{***}$ |
| Central | 0.457(9.884)$^{***}$ | 0.133(7.707)$^{***}$ | -0.296(9.294)$^{***}$ | -0.004(0.213) | -0.131(7.662)$^{***}$ |
| South | 0.009(0.216) | 0.087(5.164)$^{***}$ | 0.042(1.510) | -0.041(2.225)$^{**}$ | -0.021(1.428) |
| West | 0.187(3.627)$^{***}$ | -0.013(0.715) | -0.184(5.480)$^{***}$ | 0.077(3.903)$^{***}$ | -0.070(4.123)$^{***}$ |
| Inverse Mills Ratio | 1.988(16.35)$^{***}$ | 1.102(31.38)$^{***}$ | 1.467(24.62)$^{***}$ | 1.304(23.37)$^{***}$ | 1.079(34.07)$^{***}$ |
| Percentage of Positives | 84.3 % | 41.9 % | 74.3 % | 31.2 % | 44.6 % |
| R-squares | 0.297 | 0.531 | 0.336 | 0.489 | 0.504 |

Note: Numbers inside parenthesis are asymptotic *t*-values.

Table 3. Recovered Parameter Estimates for Health Concern Variables.

| | Beef | Pork | Chicken | Turkey | Fish |
|---|---|---|---|---|---|
| Fat | -0.164 | -0.029 | 0.112 | 0.078 | 0.069 |
| Cholesterol | -0.158 | -0.027 | 0.108 | 0.074 | 0.065 |

Table 4. Elasticities for Health Concern Variables.

| | Beef | Pork | Chicken | Turkey | Fish |
|---|---|---|---|---|---|
| Fat | -0.30817 | -0.50616 | 0.44202 | 0.73550 | 0.60487 |
| Cholesterol | -0.29787 | -0.47190 | 0.42654 | 0.69321 | 0.57484 |

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