

Integration of a Product Choice Model and a Latent Variable Model of Nutrition Information

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Abstract: We develop and estimate an integrated discrete choice model system of product choice and nutrition information for prepared frozen meals in the United States in the period from 1993 to 1998, when government regulation of nutrition labeling changed from voluntary to mandatory. The model links consumer characteristics (e.g., income, knowledge about nutrition, nutrition label use) to product characteristics (e.g., prices, nutritional attributes) and allows us to obtain consumer preference parameters and demand elasticities with regard to product characteristics. We find that prices, advertising, price reductions, and consumer preferences for taste have a significant effect on the demand for prepared frozen meals, whereas knowledge about nutrition and nutrition label use do not. Using the estimated demand parameters we then evaluate the impact of the new mandatory labeling policy. The results show that consumer preferences and purchasing patterns within the prepared frozen meals category did not change significantly after the implementation of mandatory nutrition labeling. [EconLit Q130, L110, L150].

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Introduction

The main goal of this paper is to address problems of diet and public health in the United States by assessing the determinants of consumer choices of food products, including the role of privately and publicly provided information about nutrition. New information about the linkages between diet and health and the communication of this information to the general population through private and public campaigns has led to increased demand for higher quality foods in the United States in the last fifteen years. The availability of foods with improved nutritional profiles has also increased during this period. Yet many Americans, adults and children, have poor diets and are becoming overweight at far greater numbers than ever before. According to the American Heart Association, the levels of obesity in the United States increased from 25 percent in 1976-1980 to 33 percent in 1988-1991. In the late 1990s, one in two American adults and one in four American children were overweight or obese. The effects are not only cosmetic: the problems of nutrition and obesity foster many deadly ills, from hypertension and heart disease to diabetes and cancer. The estimated cost of this epidemic to the general public health budget by 2020 will run into hundreds of billions of dollars.

The paper addresses these issues by investigating consumer choices of products in the category of prepared frozen meals in the period from 1993 to 1998. This category was chosen because it includes products that are increasingly important in consumer diets and are heavily promoted and advertised by the food industry. These foods also have nutritional profiles that may contribute to weight and obesity problems among American consumers. In addition, during this period in 1994, the Nutrition Labeling and Education Act (NLEA) went into effect requiring mandatory nutrition labeling on virtually all packaged foods. The regulation was implemented to

give consumers a tool to make informed purchase decisions and to encourage manufacturers to improve the nutritional profiles of products. One of the primary goals of the study is to evaluate the effectiveness of the NLEA. This task is particularly significant because government programs designed to improve health by changing diets focus entirely on the provision of information (education, public information campaigns, and regulation of advertising and labeling).

Our purpose is to provide new understanding of how the increased provision of consumer information about nutrition can lead to better individual food choices in the market place. In contrast to the existing work on consumer choices of foods and information provision, based primarily on aggregate product level data or on disaggregate consumer level survey data, our study continues a line of research in the area of discrete choice demand and latent variable models and combines both aggregate store level product data and disaggregate individual consumer level survey data (see Mojduszka et al. 2001). Adding consumer level data allows us to extract precise estimates of the distribution of consumer utilities, which is impossible to do from an aggregate demand system alone. On the other hand, consumer survey data alone (e.g., the Continuing Survey of Food Intakes by Individuals (CSFII) and the Diet and Health Knowledge Survey (DHKS)) cannot give precise estimates because they do not provide information on several important market variables (e.g., prices, advertising, brand strategies) that influence consumer choices of foods and thus diets. The data used in this study include IRI Info-scanTM Data, Nutritional Quality Change Data at the University of Massachusetts, National Leading Advertisers Data, USDA Diet and Health Knowledge Survey Data, and Consumer Demographics Data.

Our approach draws from and expands on models and methodologies for analysis of consumer and producer behavior in differentiated product markets as reported in the theoretical literature. We will make particular use of the discrete choice models developed by McFadden (1978), Berry (1994), and Berry et al. (1995). These models provide an effective approach for the theoretical modeling and empirical estimation of consumer demand and producer supply parameters in differentiated product markets and are consistent with a structural model of equilibrium in oligopolistic industries. However, to date these models have failed to account for the relationship between consumer preferences and knowledge about nutrition. Consumer preferences were treated as exogenous. Our work expands on previously used discrete choice models by treating consumer preferences as endogenous, by assessing the effects of horizontal and vertical quality attributes more thoroughly, and by considering not only media advertising but also in-store marketing efforts. Our study is the first to take into consideration the interdependence between consumer preferences and consumer knowledge of nutrition and thus offers more precise estimates of the demand parameters that are crucial for the design of effective nutrition information programs and for the marketing and promotion of food products by manufacturers.

First, we develop a database that integrates product level scanner purchase data, product characteristics data (including information on the nutritional composition of food products), consumer characteristics data (including information on consumer knowledge of nutrition and nutrition label use), and manufacturers' marketing efforts data (including advertising) for products in the prepared frozen meals category. This database is necessary and crucial in our approach. Second, we develop, specify, and estimate a discrete choice demand model for the

selected food category assuming endogenous consumer preferences and knowledge about nutrition. We incorporate nutrition information measures in an integrated discrete choice model system of product choice and nutrition information. No studies to date use this approach. This enables us to further assess the links between consumer knowledge about nutrition and nutritional quality choices. Third, we evaluate the implications of the results of the study for nutrition policy in the United States.

Previous Work and Approaches

Our paper is intended to move beyond existing work on the relationship between nutrition information and demand for foods or nutrient intakes. Studies by Brown and Schrader 1990, Capps and Schmitz 1991, Gould and Lin 1994, Chern et al. 1995, Variyam, Blaylock, and Smallwood 1996, for example, draw attention to the relationship between nutrition information and demand for diets, but they are limited by their primary focus on aggregate data or on disaggregate data. Brown and Schrader (1990) and Chern et al. (1995), for example, explore the effects of information by examining aggregate national consumption and price data for cholesterol and the fats and oils. Their index of cholesterol information shows that the increase in information about cholesterol decreased per capita egg consumption and that cholesterol information reduced consumption of butter and lard, but not necessarily of all fats and oil. Variyam et al. (1996) examined the determinants of fiber intake of individuals who plan household meals using the CSFII and the DHKS. The study found that although higher income was associated with greater knowledge about the fiber content of foods, as people's incomes increased, they reduced fiber consumption, despite its health benefits. Variyam et al. raise interesting and important questions about the relationship between nutrition information and the

income effect, though they cannot account for a more complete range of factors that influence consumer choices of foods. These studies, while advancing our knowledge of the relationship between information and consumer choices of foods, are limited by their reliance on limited data sets.

In addition, there have been relatively few empirical studies of the effects of the NLEA. Our paper is intended to address this gap in the literature by evaluating the effectiveness of this recently promulgated regulation. Here, too, existing studies use aggregate or disaggregate data in their analyses. For example, Finke (2000) utilized the data from the CSFII and the DHKS. He found a strong relationship between education and fat intake. In her work, Moorman (1998) investigated the impact of market information related to the NLEA on the nutritional quality of food product offerings, on the nature of competitive rivalry among manufacturers, and on consumer activism in using information. Mojduszka et al. (1999) examined nutritional quality changes in product offerings in five selected food categories using store level data. The authors found that no significant changes occurred in the average nutritional quality of food products offered for sale by manufacturers after the implementation of the NLEA. In this sense, Mojduszka et al. (1999) confirmed Moorman's findings that changes in information may confer benefits on the market but that these benefits might be more limited in scope than previously theorized (Caswell and Padberg 1992, Moorman 1998).

The most innovative and unique aspect of our work is that it moves beyond the studies described above to integrate several behavioral models and several data sources. As a result, our conclusions provide important insights into the economic forces that tend to limit the efficient provision and use of nutrition information in consumer choices of foods. We analyze how

consumer tastes, consumer characteristics (including knowledge of nutrition and nutrition label use), product characteristics (including nutritional content of foods), and manufacturers' marketing strategies (including advertising) influence individual food choices. We adopt a non-standard economic assumption that consumer preferences are endogenous. This allows us to further analyze the links between consumer knowledge of nutrition, nutrition label use, and individual nutritional quality choices.

A Discrete Choice Model of Consumer Demand for Prepared Frozen Meals

In this paper, we assess the links between consumer knowledge about nutrition and nutritional quality choices. We develop, specify, and estimate a discrete choice demand model for the selected food category assuming endogenous consumer preferences and knowledge about nutrition. To address this problem of estimation, we build on our previously completed work on discrete choice modeling of consumer demand. Mojduszka et al. (2001) provide a model of individual consumer utility and demand that is explicitly aggregated to obtain product level demands. It therefore already contains a framework for analyzing aggregate and disaggregate data sources. However, consumer choice of food products may be further conditioned by nutrition information. To account for this possibility we assume that consumer choice of food products and nutrition information are correlated, implying a simultaneous system of equations. We incorporate nutrition information measures in an integrated discrete choice model system of product choice and nutrition information (Ben-Akiva and Bowman 1998). In this new model, the distribution of consumer utilities depends on both measured and unmeasured individual characteristics. These determine preferences for product attributes (some of which are unobserved) and hence determine demand.

The changes incorporated into the new model allow us to estimate three sets of parameters using a sequentially estimated nested multinomial logit system. The first set of parameters quantifies the effect of measured individual characteristics on tastes for product attributes. The second set measures the importance of unmeasured individual characteristics in determining preferences for product attributes. The third set allows us to estimate the effect of product attributes on the mean utility of a product. In other words, the first two sets give direct evidence on the extent to which the demand parameters can be explained by individual characteristics. The aggregate data are then used to estimate the additional parameters that determine the relationship between product attributes and the mean utility levels of the products.

By integrating a product choice model and a latent variable model of nutrition information as well as all of our data sources, we are able to obtain more precise estimates of the demand parameters that are crucial for the design of effective nutrition information programs and for the marketing and promotion of food products by manufacturers and distributors. The results of the study may thus contribute to precise answers to the question of how consumer information about nutrition can lead to better individual food choices in the market place.

To obtain our demand system for differentiated prepared frozen meals, we use a discrete choice model of individual consumer behavior (see McFadden, 1978; Berry, 1994; Berry, Levinsohn, and Pakes, 1995; Nevo, 1997; as well as the product differentiation literature by Shaked and Sutton, 1982; Perloff and Salop, 1985; Bresnahan, 1987). We then apply the estimated parameters of the demand system to evaluate the effectiveness of mandatory nutrition labeling policy.

Discrete choice models utilize indirect utility functions and assume that the level of utility that a consumer derives from a given product (brand) depends on both product characteristics and

consumer characteristics. Therefore, we specify the maximum utility derived by consumer i from consuming product j in time period t as:

(1)

$$u_{ijt} = \sum_k x_{jkt} \beta_{ik} + \xi_j + \Delta \xi_{jt} + \varepsilon_{ijt}$$

where

(2)

$$\beta_{ik} = \bar{\beta}_k + \sum_r D_{irt} \beta_{kr}^m + \beta_k^{um} v_{ik}.$$

The products competing in the market are indexed as $j=0, 1, \dots, J$. Product $j=0$ is the outside good, so that u_{i0} is the utility the consumer derives if she does not purchase any of the J brands and allocates her income to other purchases. The x_{jkt} 's are observed product characteristics, including price. The ξ_j is the national mean of the unobserved product characteristics and the $\Delta \xi_{jt}$ is a quarter specific deviation from this mean. The β_{ik} 's are the preference parameters of consumer i for product characteristic k . The D_{irt} 's are measured consumer characteristics, where r is a consumer characteristic, including knowledge about nutrition and use of nutrition labels, and v_{ik} 's are unmeasured consumer characteristics from a multi-variate normal distribution. Therefore, the β_{ik} 's are made up of a first component that captures the average preferences (tastes) of all consumers for an attribute and a second component that represents the deviation of individuals from the average preference based on their own characteristics. This latter component is made up of deviations based

on both measured (m) and unmeasured (um) consumer characteristics. Finally, the ε_{ijt} 's represent error terms in individual preferences.

We find the consumer level choice model by substituting equation (2) into equation (1) to obtain:

(3)

$$u_{ijt} = \delta_{jt} + \mu_{ijt}, \text{ for } j = 0, 1, \dots, J,$$

where

(4)

$$\delta_{jt} = \sum_k x_{jkt} \bar{\beta}_k + \xi_j + \Delta \xi_{jt},$$

and

(5)

$$\mu_{ijt} = \sum_{kr} x_{jkt} D_{irt} \beta_{kr}^m + \sum_k x_{jkt} v_{ik} \beta_k^{um} + \varepsilon_{ijt}.$$

The indirect utility of consumer i from product j in time period t is now expressed as the mean utility, referred to as δ_{jt} 's, and the mean zero heteroscedastic deviation from that mean, μ_{ijt} , that captures the effects of the random coefficients, which reflect individual consumer characteristics. In this case, the contribution of x_k units of the k^{th} product characteristic to the utility of consumer i is given by:

(6)

$$(\bar{\beta}_k + \beta_{kr}^m D_{irt} + \beta_k^{um} v_{ik}) x_{jkt}$$

and varies across consumers. The mean of the utility from good j , δ_{jt} , is entirely determined by the product characteristics and thus represents a product specific component that does not vary with consumer characteristics. On the other hand, a deviation from that mean, μ_{ijt} , depends on the interaction between consumer and product specific characteristics. As a result, consumers who have a preference for fat, for example, will tend to attach high utility to all fatty products, and this will induce large substitution effects between fatty products. The parameters of the model are $\theta=(\delta, \beta^m, \beta^{um})$. The vector δ includes the linear parameters and the vectors β^m and β^{um} contain the non-linear parameters.

We obtain the aggregate demand system by summing the choices implied by the individual utility model over the distribution of consumer characteristics in the population. We denote the vector of measured and unmeasured individual characteristics by w , therefore,

(7)

$$w = (D, v, \varepsilon)$$

and we denote its distribution in the population by P_w .

Each consumer chooses one unit of the good that maximizes its utility, therefore, aggregate demand for good j is given by the integral of the density of consumer characteristics over the set of product characteristics that imply a preference for good j :

(8)

$$s_{jt}(\delta, \beta^m, \beta^{um}, x) = \int_{A_{jt}} P_w(dw) = \int_{A_{jt}} P_\varepsilon(d\varepsilon) * P_D(dD) * P_v(dv)$$

where

(9)

$$A_{jt}(\delta, \beta^m, \beta^{um}; x) = \{w : \max_{r=0,1,\dots,J} [u_{irt}(w; \delta, \beta^m, \beta^{um}, x)] = u_{irt}\}.$$

By multiplying the market share equation by the number of consumers in the market, M , we obtain the J -vector of demands as $M*s(\delta, \beta^m, \beta^{um}, x)$. We model consumer heterogeneity as a function of the empirical non-parametric distribution of consumer characteristics without imposing any arbitrary functional forms on this distribution. Thus, given the assumptions on the distribution of the unobserved variables (v and ε), we can compute the integral in the market share equation analytically or numerically.

The Multinomial Logit Model

In order to solve the integral given in equation (8) one option is to assume that consumer characteristics or consumer heterogeneity enters the model only through the additively separable random shocks, ε_{ijt} , and that these shocks are independently and identically distributed across both

consumers and products with a Type I extreme value distribution. This assumption reduces the model to the classic multinomial logit model and gives us the following market share equation:

(10)

$$s_{jt} = \frac{\exp^{\delta_{jt}}}{1 + \sum_{j=1}^J \exp^{\delta_{jt}}} \text{ for } j = 0, 1, \dots, J.$$

We note that, in this case, there is a closed form for the market share equation and there is no need to compute any integral.

However, this specification is problematic despite its computational simplicity. The utility function is additively separable into two terms, one determined entirely by the product characteristics, δ_{jt} , and one determined by the consumer characteristics, ε_{ijt} . The utility function expressed in this form implies that all substitution effects depend only on the δ_{jt} 's. Since there is a unique vector of market shares associated with each δ -vector, the additively separable specification says that the cross-price elasticities between any two products are proportional to market shares. That is, the logit model restricts consumers to substitute toward other products in proportion to market shares, regardless of characteristics of the products. The additively separable specification also implies that two products with the same market share will have the same own-price elasticity. In an oligopoly setting, this is especially problematic because the two products would have to have the same markup over marginal cost. We expect markups to be determined by more than market shares, including the number of competing products that are close in product space and lower

marginal utilities of income for consumers who buy more expensive goods. The price elasticities of the market shares defined by equation (10) are:

(11)

$$\eta_{jt} = \frac{\partial s_{jt}}{\partial p_{jt}} \frac{p_{jt}}{s_{jt}} = \begin{cases} \beta p_{jt} (1 - s_{jt}), & \text{if } j = l; \\ -\beta p_{lt} s_{lt}, & \text{otherwise} \end{cases}$$

and the cross-price elasticities are proportional to product market shares whereas the own-price elasticities are proportional to own prices.

The main conclusion is that the classic logit model of discrete consumer choice of products does not allow for interactions between product characteristics and consumer characteristics and that it explains differences in market shares by allowing only the mean utility from good j for the aggregate consumer to change. Despite these disadvantages, we estimate the multinomial logit model here because it is relatively easy to estimate and provides a starting point for comparison to the random coefficients discrete choice model that we will finish developing and estimating in the near future.

Data, Variables, and Estimation Technique

Data and Variables

To estimate the models described in the previous section, we need data for the following variables: market shares and prices of prepared frozen meal products; their product characteristics, advertising and promotion; and information on the distribution of consumer characteristics.

We obtain the data on market shares, prices, and in-store marketing efforts for prepared frozen meal products from the IRI Infoscan Data Base at the Food Markets Branch, Economic Research

Service, U.S. Department of Agriculture. These data are collected continuously by the marketing firm using scanning devices in a national random sample of supermarkets located in 64 metropolitan and rural areas of the United States. We calculate market shares by converting the aggregate national quarterly volume of product sales into the number of servings sold and dividing them by the total potential number of servings in a quarter. This potential is assumed to be one serving per person per day. The outside good market share is defined as the residual between one and the sum of the observed market shares. The results presented below are computed for the 200 frozen dinner, entree, and frozen pizza products with the highest national market shares in each quarter from 1993 to 1998.

We obtain the price variable by dividing the quarterly dollar sales for each product by the number of servings sold and we deflate it by the Consumer Price Index. The dollar sales are calculated using the real average pre-manufacturer coupon transaction prices paid by consumers. The dollar sales data do not account for the value of coupons that might be used by consumers. However, if coupons are used uniformly across products this will not affect our analysis.

The IRI data contain information on in-store marketing efforts. We use the percent of dollar value of all prepared frozen meals that were sold with price reductions, in-store displays, and in-store featuring to evaluate the impact of these variables on consumer choices of prepared frozen meals. The variation in these variables is shown in Table 1.

We match the Infoscan quarterly market share, price, and other data for each product with four other data sources. First, we match the IRI data with the quarterly expenditures on advertising for these products taken from the Leading National Advertising data base for 1993-1998. These data have been collected for 11 different types of mass media (e.g., network television, spot television,

cable networks, national spot radio, network radio, newspapers, magazines). We use only the total average advertising expenditures on all of the 11 types of mass media (see Table 1).

Second we match the IRI to the Nutritional Labeling Data developed at the University of Massachusetts. The National Infoscan Data do not provide information on the amounts of nutrients in food products. Thus, the information on market shares and prices has to be matched with information on the nutritional content of the respective frozen dinner, entree, and pizza products. The Nutritional Labeling Data include a complete census of all products in the most popular package size offered in 33 food product categories in a representative super-store in New England for the years 1992 through 1999. These data were not collected in 1996 and 1998. Because nutritional profiles were changing slowly during this period (Mojduszka et al., 1999), we use 1997 nutritional data for 1996 and 1999 data for 1998. Although the quality change data set provides information on all the products offered in a large super-store, it does not contain information on all the products offered at the national level. As a result, some products that appear in the scanner data are missing in the supermarket data. In such cases where it is impossible to match the respective products exactly, we create the average nutrient content values for the missing products based on similar products and use these values in our estimations. Table 2 summarizes the extent of the data match between the two data sources.

In our discrete choice model of consumer demand, we include the following nutrient content variables: calories, fat, cholesterol, sodium, fiber, protein, and vitamins A and C. The levels of nutrient content variables for each product in the data set are based on standardized serving sizes that correspond to the reference amounts consumed on average by an adult person as defined under the Nutrition Labeling and Education Act (NLEA). The levels of nutrients were converted to the corresponding reference amounts if the serving size stated on the product label was not equal to the

reference amount. This conversion allows comparison of different products for their nutritional content. In addition, we create two product specific dummy variables that reflect further quality attributes of frozen meal products. These two attributes are whether the product contains meat or not and whether it is an ethnic food or not. Table 3 provides statistics for the attributes for the sample of 200 products of prepared frozen meals used in the analysis below.

Third we obtained information on the distribution of consumer knowledge about nutrition and nutrition label use by sampling individuals from the Diet and Health Knowledge Survey (DHKS) for the 1994-1996 time period. We assume that consumer knowledge and label use did not change in 1993-1994 and in 1996-1998. Therefore, we apply the 1994 data for 1993 and the 1996 data for 1997 and 1998. The DHKS surveys 1,966 individuals, 20 years of age or older, who are the main meal planners in their households. The survey includes their answers to questions concerning attitudes toward and knowledge of nutrition, food safety, and diet and health, as well as their use of nutrition labels. Here we use only those questions from the DHKS that relate to fat and nutrition panel use because we hypothesize that fat plays an important role in consumer choices of prepared frozen meals, as does knowledge about fat and use of nutrition panels. The latter can allow consumers to precisely evaluate the nutritional quality of foods they choose. All packaged foods have been required to carry nutrition panels since May 1994.

Consumer knowledge cannot be directly observed but only indirectly measured using observed responses to the specific questions. In the survey, there are ten questions with regard to general knowledge about fat and saturated fat. We construct a General Fat Knowledge variable as a score that ranges from zero to ten. Ten is the highest score that an individual can get by responding correctly to all of the questions asked. Examples of questions on general knowledge about fat include: Which has

more fat, yogurt or sour cream? hamburger or ground round? Which has more saturated fat, butter or margarine? We also construct a Specific Fat Knowledge variable as a score out of five questions related to more specific knowledge about fat. Examples of questions on specific knowledge about fat include: If a food has no cholesterol is it also low in saturated fat? And is cholesterol found in vegetables/vegetable oils? In addition, we construct a binary variable Nutrition Panel Use. This variable accounts for consumers' use of nutrition panels and equals one when the answer to the question, do you use the nutrition panel, is yes (even if consumers state that they use nutrition panels sometimes or rarely) and zero otherwise. By incorporating this information in our model, we are able to estimate how consumer knowledge of fat and use of nutrition panels affect consumer choices of prepared frozen meal products. We assume that the consumer knowledge variables are endogenous to our demand system.

Finally, we obtain information on the distribution of consumer demographic variables by sampling individuals from the Current Population Survey (CPS) for each year. Consumer per capita income is constructed by dividing household income by the size of the household. The CPS data are representative of the national population statistics from the Bureau of the Census. Table 4 reports the sample statistics on consumer knowledge about fat, consumer use of nutrition panels, and consumer demographics.

Estimation Technique

We use the tree extreme value estimation method that can be expressed as a nested sequence of multinomial logit models, and consistent parameters can be obtained from a sequence of multinomial logit estimators. This sequential procedure depends on estimating the parameters of the lower level model of consumer preference tree (in our case a latent variable model of nutrition

knowledge) by maximizing the log likelihood function and using the estimated values of the parameters of that model for the higher level model (in our case a discrete choice demand model for prepared frozen meals). The estimated parameters of the higher level model are thus conditioned on the estimates of the lower level model. We can also say that the lower level model is supplying expected maximum utility, or logsum variables, to the higher lever model.

Estimation Results and Analysis

We present the results for the multinomial logit specification of the discrete choice model of consumer demand for prepared frozen meals. The logit model provides an easy-to-estimate reference point despite the restrictive substitution patterns that it generates.

To estimate the model, we use data for the 200 products with the highest national sales in all of the quarters from 1993 to 1998. The combined share of these 200 products varies from 62 to 65 percent of the total national sales of prepared frozen meals in each quarter.

We present the logit model results and evaluate the importance of instrumenting for price and the effects of the different sets of instruments used. Table 5 shows the estimates obtained by regressing the market share of a particular product relative to the total market size ($\ln(S_{jt}) - \ln(S_{0t})$) on product characteristics (including price), advertising and in-store marketing efforts, brand specific dummies, and consumer characteristics (including consumer knowledge about fat and nutrition panel use). In the first column of Table 5, we report the results of ordinary least squares regression applied to the logit utility specification for 4,800 observations (200 products in 24 quarters, 1993-1998). In the second and third column, we re-estimate the logit utility specification to account for the possible correlation between the price variable and the unobserved characteristics (or $\Delta\xi_{jt}$ in our case) by using an instrumental variable estimation technique. In the second column, we use quarterly average

product prices in all 24 quarters as instruments in a two stage least squares regression and in the third column, we use different instruments: lagged values of prices (see Hausman, 1996; Cotterill and Haller, 1996 for a detailed description of the method).

The use of instruments generates changes in several of the parameter estimates. Most importantly, the coefficient on price more than triples and thus shows a dramatic increase in absolute value. The coefficient on price is similar in the two regressions that use instruments. The first stage R^2 and F-statistics for the instrumental variable regressions are high, suggesting that the instruments we use have some explanatory power. The results indicate that correcting for the possible endogeneity of prices is important. We can also see the importance of unobservables ($\Delta\xi_{jt}$) by examining the fit of the logit model. The instrumental variable method gives a first stage R^2 of 0.88. This implies that only 12 percent of variance in mean utility levels is due to the unobserved characteristics ($\Delta\xi_{jt}$).

In our modeling of consumer choice of prepared frozen meals, we include consumer characteristic variables to account for the heterogeneity of consumer preferences. In the logit specification, these variables enter the model only through the error term (Berry, Levinsohn, and Pakes, 1995). Therefore, their inclusion reduces the omitted-variable bias in the mean of consumer utility. The omitted variable bias could still be present because other variables could be omitted.

The coefficients on the consumer characteristic variables show the change in the valuation of frozen meals as a function of these characteristics. The results suggest that the valuation of frozen meals significantly increases with consumer household size and significantly decreases with consumer income. Increases in general and specific fat knowledge, and age decrease consumer valuation of frozen meals. However, these changes are statistically insignificant. Finally, the positive coefficient

on the nutrition panel use variable suggests that consumer valuation of frozen meals increases with increased use of nutrition panels but the coefficient is not statistically significant. We plan to explore alternative specifications of the nutrition knowledge variables. For example, Variyam et al. (1996) found that nutrition knowledge was not a significant factor for dietary fiber intake but that nutrition awareness and attitude towards nutrition was significant.

The logistic regression also includes the advertising variable, which has a positive and statistically significant coefficient. With the exception of the OLS specification, the estimated effect of advertising is almost the same in all specifications. A larger value of the advertising coefficient in the OLS column is a result of the correlation between unobserved characteristics and advertising: brands with larger market shares tend to have higher unobserved quality and are advertised more. Once we control for this potential endogeneity, the values of the coefficients are almost the same. Non-linear effects in advertising were also tested and were found to be statistically insignificant.

In all regressions, we include zero-one time dummy variables to account for possible structural changes in consumer preferences in the period before and after the implementation of mandatory nutrition labeling. None of the time-dummy variables are statistically significant. Therefore, the results of this test for structural change show that, in the period under examination, no significant changes occurred in consumer preferences for prepared frozen meals. Increases in the quantity and quality of information available to consumers after the implementation of mandatory labeling requirements did not significantly alter consumer preferences and purchasing patterns.

Table 6 presents a sample of the calculated demand elasticities with respect to the continuous attributes of frozen meals, their own prices, and advertising. The elasticities are computed based on equations (6) and (11), and on the estimates of the coefficients reported in Table 5. For each attribute,

the left column shows the value of that attribute per serving and the right column shows the calculated elasticity. The elasticities for price and sodium are negative and the elasticities for calories, fat, and advertising are positive. Each entry gives the percentage change in market share of the product with a one percentage point change in its own price, its own product attributes, and its own advertising. For example, the top of Table 6 shows that for the average product a 1 percent increase in price, holding other variables constant, would result in a 2.43 percentage point decrease in market share of this product. An increase of 1 percent in fat content would lead to a 0.10 percentage point increase in market share. We can conclude that, on average, changes in prices and advertising would lead to the largest changes in market shares. On the other hand, changes in the nutritional characteristics of products would lead to relatively small changes in market shares. This means that consumers are less sensitive to changes in nutritional characteristics than to changes in prices and advertising.

Implications for Nutrition Labeling Policy

In this section, we examine the implications of the estimated demand system for government policies that require the provision of information about the nutritional quality of food products.

Our model is defined in terms of a utility function that assigns values to different possible combinations of product attributes as a function of consumer characteristics. We compute own- and cross-price elasticities as well as elasticities of demand with respect to product attributes for prepared frozen meal products. The results have important implications for analysis of the effectiveness of government regulation of nutrition labeling of processed foods.

The analysis of consumer preference parameters for the nutritional attributes of prepared frozen meals reveals that consumers value only a very few nutritional characteristics of these products. Both calories and fat are valued positively but sodium is valued negatively. Products

containing meat and products that can be characterized as ethnic foods are also valued positively. Our findings with regard to the positive valuation of calories, fat, products containing meat, and ethnic foods can be linked to strong consumer preferences for taste as opposed to nutrition and health-related attributes.

The calculated elasticities of demand show that product prices and advertising play a much greater role in consumer choices of prepared frozen meals than do nutritional characteristics. Nor does consumer knowledge about fat and nutrition panel use appear to have a significant impact on consumer choices.

The results of our test for structural change show that, in the period under consideration, no significant changes occurred in consumer preferences for prepared frozen meals. Therefore, we conclude that the increased quantity and improved quality of information available to consumers after the implementation of mandatory nutrition labeling did not lead to changes in consumer preferences and purchasing patterns.

The new mandatory labeling policy was implemented in order to give consumers a tool to learn more about the nutritional quality of the foods they eat. Ultimately, the labeling policy was meant to encourage consumers to demand foods with better nutritional profiles. Based on our results, it appears that to date the mandatory nutritional labeling policy has been ineffective in influencing consumer demand for prepared frozen meals. The investment already made in nutrition labeling might generate a larger payoff with a more active educational campaign.

Summary

In this paper we develop an integrated discrete choice model system of product choice and nutrition information to investigate what affected consumer demand for prepared frozen meals from

1993-1998, a period when government regulation of nutrition labeling changed from voluntary to mandatory. The model links consumer characteristics (e.g., income, knowledge about nutrition, nutrition label use) to product characteristics (e.g., prices, nutritional attributes) and allows us to obtain consumer preference parameters and demand elasticities with regard to product characteristics for prepared frozen meal products. The estimated consumer preference parameters and demand elasticities are then used to evaluate the impact of the new mandatory labeling policy.

The results show that price, advertising, price reductions, and consumer preferences for taste have a significant effect on the demand for prepared frozen meals whereas concerns and knowledge about nutrition and health do not. Based on the results, we conclude that consumer preferences and purchasing patterns within the prepared frozen meals category did not change significantly after the implementation of mandatory nutrition labeling.

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Table 1. Market Shares, Prices, Advertising, and Promotion of Products in Sample.

Variable	Mean	Standard Deviation	Min	Max
Prices (\$ per serving)	2.00	2.09	0.38	12.29
Share within Frozen Prepared Meals Market (%)	0.36	0.82	0.04	2.7
Price Reduction (% \$)	14.01	5.16	0.41	43.99
Display (% \$)	3.08	3.06	0.10	17.00
Feature (% \$)	13.80	18.94	0.29	45.44
Advertising (Million \$)	0.09	0.12	0.00	3.44

Table 2. Summary of Matched Scanner Data to Nutritional Labeling Data.

	# of Scanner Observations (Per Quarter 1993-1998)	# of Observations Matched to Nutritional Labeling Data					
		1993	1994	1995	1996 ^a	1997	1998 ^a
Frozen Entrees and Dinners	186	124	130	128	131	131	134
Frozen Pizza	14	9	8	10	9	9	10
TOTAL	200	133	138	138	140	140	144

^a Due to the lack of availability of 1996 and 1998 supermarket data, 1997 nutrition label data are matched to the 1996 scanner data and 1999 is matched to 1998.

Table 3. Summary of Statistics on Characteristics of Products in Sample.

Variable	Mean	Standard Deviation	Min	Max
Calories	185.76	54.07	68.75	550.00
Fat (g)	7.42	4.65	0.63	30.00
Cholesterol (mg)	22.34	13.52	4.16	108.33
Sodium (mg)	434.03	158.54	195.45	1033.33
Fiber (g)	1.92	2.49	0.00	3.45
Protein (g)	8.81	3.15	0.53	23.33
Vitamin A (%)	7.82	11.03	0.00	48.78
Vitamin C (%)	4.24	4.22	0.00	15.91
Calcium (%)	6.90	6.49	0.00	29.55
Package Size (oz)	13.01	8.35	5.00	96.00
Meat Dummy (=1 if contains meat)	0.64	0.48	0.00	1.00
Ethnic Dummy (=1 if ethnic food)	0.24	0.46	0.00	1.00

Table 4. Fat Knowledge, Nutrition Panel Use, and Demographic Variables.

Variable	Mean	Standard Deviation	Min	Max
General Fat Knowledge	7.3	5.7	0	10
Specific Fat Knowledge	2.6	1.9	0	5
Nutrition Panel Use	0.76	0.80	0	1
Income (\$)	14, 698	12,362	0	190,000
Household Size	2.79	1.75	1	11
Age	32	29	22	89

Table 5. Estimates of the Logistic Discrete Choice Model, 1993-1998.

Variable	OLS	Instrumental Variable Method	
		Average Quarterly Price	Lagged Price
Calories	0.019* (4.3198)	0.030* (4.0547)	0.028* (4.1436)
Fat (g)	0.010* (5.3645)	0.009* (4.6243)	(0.010)* (4.6822)
Cholesterol (mg)	0.001 (0.8744)	0.008 (1.0002)	0.009 (1.0845)
Sodium (mg)	-0.075* (-6.2159)	-0.031* (-4.2610)	-0.040* (-4.4371)
Fiber (g)	0.004 (0.8860)	0.003 (0.6402)	0.002 (0.7461)
Protein (g)	0.092 (0.7706)	0.051 (0.4103)	0.070 (0.6350)
Vitamin A (%)	0.010 (0.3001)	0.015 (0.3766)	0.013 (0.3475)
Vitamin C (%)	0.035 (0.3978)	0.018 (0.5197)	0.018 (0.5322)
Meat Dummy (=1 if Contains Meat)	0.308* (4.4088)	0.191* (3.6254)	0.213* (4.0287)
Ethnic Dummy (=1 if Ethnic Food)	0.497* (3.9297)	0.300* (3.4796)	0.277* (2.9549)
Package Size (oz)	-0.015 (-0.3473)	-0.001 (-0.2040)	-0.002 (-0.3005)
Price (\$ per serving)	-5.312* (-3.9670)	-18.540* (-4.2125)	-18.041* (-3.9936)
Advertising (M\$)	0.062* (3.1187)	0.057* (3.2013)	0.059* (3.1519)
Price Reduction (%)	0.162* (2.6721)	0.202* (2.5876)	0.207* (2.4919)
Display (%)	0.252 (1.4662)	0.342 (1.5024)	0.320 (1.5245)
Feature (%)	0.092 (1.3390)	0.039 (1.2432)	0.043 (1.3040)
General Fat Knowledge	-0.348 (-1.3796)	-0.325 (-1.4862)	-0.319 (-1.3989)
Specific Fat Knowledge	-0.002 (-0.3480)	-0.001 (-0.2564)	-0.001 (-0.3101)

Table 5. Estimates of the Logistic Discrete Choice Model, 1993-1998. (Continued)

Variable	OLS	Instrumental Variable Method	
		Average Quarterly Price	Lagged Price
Nutrition Panel Use	0.245 (0.9848)	0.035 (0.8538)	0.150 (0.9327)
Log of Income	-0.986* (-2.8498)	-0.759* (-2.7879)	-0.732* (-2.5476)
Log of Age	-0.003 (1.0112)	-0.001 (0.8930)	-0.001 (0.9204)
Household Size	0.493* (2.2928)	0.503* (2.6490)	0.501* (2.6376)
R ² (adjusted)	0.65	0.88	0.89
F-statistic	2476	3169	3310

Dependant variable is $\ln(S_{jt}) - \ln(S_{0t})$.

*Significant at the 5% level (two-tailed test).

The t-values are in parentheses.

All regressions include time dummy variables that are statistically insignificant.

Table 6. A Sample of the Calculated Demand Elasticities for the Continuous Attributes, Prices, and Advertising.

	Price/Serving		Advertising		Calories/Serving		Fat/Serving		Sodium/Serving	
Descriptive Statistics ^a										
Mean	-2.43		0.23		0.15		0.11		-0.09	
Std	0.83		0.12		0.20		0.09		0.10	
Product ^b										
1	3.51	-3.72	106.4	0.19	220.00	0.11	12.00	0.13	616.00	-0.17
2	3.02	-3.21	106.4	0.19	199.00	0.10	9.00	0.11	500.00	-0.11
5	2.05	-2.27	0	0.00	280.70	0.14	16.00	0.17	900.16	-0.25
10	1.13	-1.54	0	0.00	219.44	0.11	10.80	0.12	505.00	-0.12
100	2.27	-2.58	0	0.00	123.80	0.06	2.00	0.01	209.50	-0.04

For each variable the left column presents the value of the attribute in dollars, million of dollars, calories, grams, and milligrams respectively.

^a Descriptive statistics of elasticities in all quarters.

^b A sample of elasticities for the last quarter of 1998.