Does Nutrition Labeling Lead to Healthier Eating?

Mario F. Teisl and Alan S. Levy

Nutrient labeling is found to significantly affect consumer purchase behavior; some evidence that consumers may act as if they hold nutrient (or health risk) budgets is found. Providing nutrient information may allow consumers to more easily switch consumption away from 'unhealthy' products in those food categories where differences in other quality characteristics (e.g., taste) are relatively small between the more and less 'healthy' products, toward 'unhealthy' products in categories where differences may be relatively large (i.e., a 'substitution effect'). If this substitution effect is large, nutrient labeling may not change the overall consumption of 'unhealthy' nutrients and thus may not lead to significant changes in health risk.

Since 1980, there have been significant changes in the amount of health-related information being disseminated to food consumers by both the public and private sectors. For example, Congress passed the Nutrition Labeling and Education Act of 1990, which changed nutrition label content, coverage and presentation. In addition, food product manufacturers began placing product-specific health or nutrient-related information on food products. Several economic studies have examined the behavioral effects of providing health-related information to consumers (Brown and Schrader 1990; Putler 1987; Chang and Kinnucan 1991; Capps and Schmitz 1991; Zuo and Chern 1996; Spreen and Gao 1993; Ippolito and Mathios 1990, 96). All of these studies focused on the demand for a single commodity or a group of commodities (i.e., a commodity and its hypothesized substitutes). One possible conclusion from these studies is that providing health-related information to consumers leads to 'healthier' eating.

This conclusion may be erroneous, particularly with respect to nutrition labeling, because providing health information to consumers may have two effects. First, health-related information may induce consumers (those who did not know about the consequences of 'unhealthy' nutrient consumption) to reduce their net intake of these 'unhealthy' nutrients. Alternatively, providing health information may allow individuals to alter their consumption patterns so as to increase their utility without any change in overall health risk. For example, assume an individual wants to consume no more than a particular amount of fat per day (i.e., assume she acts as if she has a 'fat budget constraint'). Nutrition information on food products may cause her to switch consumption away from fattier products in those food categories where the difference in taste between the more and less fatty products is relatively small, toward consumption of fattier products in food categories where the difference in taste between the more and less fatty products may be relatively large. The individual alters her food consumption behavior without changing overall fat consumption (or resulting health risk). If this type of nutrient switching behavior is common, then economic research using only a limited range of products may overestimate the behavioral impacts of providing health information. The purpose here to test whether there is any evidence of this type of switching behavior.

Theoretical Framework

The model used here is based on an Almost Ideal Demand System (AIDS) framework expanded to include information effects (Piggott et al. 1996) and demographic characteristics (Muelbauer and Pashards 1981). The AIDS model is chosen because it satisfies the axioms of choice, allows imposition of adding up, homogeneity, and Slutsky symmetry restrictions and allows some forms of aggregation (Deaton and Muelbauer 1980). In addition, AIDS models have been shown to be equivalent or superior to other common demand specifications, e.g., Translog (Lewbel 1989); Log-Translog, CES-transformed AIDS,

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The authors are Assistant Professor, Department of Resource Economics and Policy, University of Maine and Chief, Consumer Studies Branch, Center for Food Safety and Applied Nutrition, U.S. Food and Drug Administration. The research was performed while Teisl was a Staff Fellow in the Consumer Studies Branch, and a Ph.D. student in the Department of Agricultural and Resource Economics at the University of Maryland.

(Castagnini, Cox and Perali 1996); Rotterdam, CBS (Gao, Wailes and Cramer 1994); LES, Indirect Addilog, Linearized AIDS, General Dynamic AIDS, Indirect Translog (Green, Hassan and Johnson 1995); and Linearized AIDS (Buse 1994).

The expanded AIDS model begins with the household's expenditure function (e):

(1a) $$\log e\,(P, U, a(S;\chi), \Omega; \varphi)/k_h = \Phi(P, a(S;\chi), \Omega; \varphi) + \beta_0 \prod P_{jt}^{\beta_j}\, U$$

where P denotes prices; U denotes utility; a(•) denotes an awareness function which is influenced by information, S, and χ, a vector of individual characteristics that may affect information access costs; Ω denotes other product-specific demand influences (such as taste or seasonality); φ denotes a vector of household demographic characteristics that may affect the relative weights given to health assessments versus other quality attributes; and k_h is a general measure of household size to deflate the budget of the household to a 'needs-corrected' per capita basis (Deaton and Muelbauer 1980). During time t,

(1b) $$\Phi(P, a(S;\chi), \Omega; \varphi) = \alpha_0 + \Sigma_i\alpha_i \log P_{it} + (1/2)\, \Sigma_i\Sigma_j\gamma_{ij}\log P_{it}\log P_{jt},$$

where

$$\alpha_i = f\{a(S;\chi), \Omega; \varphi\} = g\{S, \Omega; \chi, \varphi\},$$

where the subscripts i and j denote goods, t denotes time, and h denotes household.

Taking the derivative of (1a) with respect to $\log P_i$ yields expenditure share equations that are a function of prices, information influences, other demand influences, individual characteristics and utility:

(2) $$W_{iht} = \alpha_i + \Sigma_j\, \gamma_{ij}\log P_{jt} + \beta_i\, (\beta_0 \prod_{i\neq j} P_{jt}^{\beta_j}\, U_h).$$

For a utility maximizing household, expenditures on all goods will equal household income minus taxes and savings (Y_h). Thus, disposable income (income hereafter) can be substituted for e in the left hand side of (1a) and inverted so that U_h is a function of prices, information, demographic and other demand influences, and income. Substitution for U_h provides an estimable share equation for the i^{th} good during time t at the household level,

(3) $$W_{iht} = \alpha_i + \Sigma_j\, \gamma_{ij}\log P_{jt} + \beta_i \log(Y_{ht}/\, k_h P^*_t)$$

where $W_{iht} = \{(P_{it}\, X_{iht})/\, Y_{ht}\}$ is the share of household income spent on good 'i' (X_{iht} denotes the quantity of good i chosen by household h during time t), and $P^* = \Phi(P, a(S;\chi), \Omega; \varphi)$.[1]

A limitation often encountered by researchers is that data on market purchases are often aggregated at some level. A benefit of the AIDS framework is that it fulfills the conditions required for exact non-linear aggregation. Following Deaton and Muelbauer (1980), the individual household share equations can be aggregated across households by multiplying W_{iht} by individual household income, summing over all households, and dividing by the aggregate income:

(4) $$W_{it} = \Sigma_h\{Y_{ht}\, \alpha_i /\Sigma_h Y_{ht}\} + \Sigma_j\, \gamma_{ij}\log P_{jt} + \beta_i \log(Y_t/P^*_t)$$

where W_{it} is the share of aggregate income spent on good i in the aggregate income of all households and $\log Y_t = \Sigma_h\{Y_{ht} \log (Y_{ht}/k_h)/\Sigma_h Y_{ht}\}$.

Deaton and Muelbauer note that one can find an aggregate index, K, such that

$$\log (Y/K) \equiv \Sigma_h\{Y_{ht} \log (Y_{ht}/k_h)/\Sigma_h Y_{ht}\}$$

where Y is average household income and Y/K is the representative budget level. If cross-sectional data on Y_{ht} and k_h is available then one could calculate a value for K. Economists have typically not used this approach rather they have followed one of two practices: Y/K is either replaced by per capita income (i.e., income/population) or by per capita 'conditional' expenditures (i.e., total expenditures on the goods within the system/population).

Description of Data

The data are from a cooperative effort between industry (Stop & Shop Supermarkets) and the U.S. Food and Drug Administration to test the efficacy of nutrition shelf labeling (brand specific nutrition information provided on the shelf in conjunction with the products' unit and item price information). The nutrition information carried on the shelf label consisted of a simple message highlighting whether the food product was low or

[1] Most empirical studies using AIDS models have used the Linearized AIDS model which substitutes P* with Stone's price index. Although simpler to estimate, the Linearized AIDS provides inconsistent parameter estimates (Buse 1994).

reduced in fat, cholesterol, sodium or calories (Figure 1).

Figure 1. Sample Shelf Label.

A total of 25 Stop & Shop Supermarket stores in Connecticut, Rhode Island, New Hampshire and Massachusetts were included within the experiment. Thirteen stores were designated as the treatment group, with the remaining 12 stores designated as the control group. During 1985, both the treatment and control stores began using shelf tags to provide products' unit and item price information to consumers. From 1986 to 1989, the 13 stores in the treatment group implemented a nutrition education program. During the first year of the program (1986), treatment stores exhibited shelf tags augmented with nutrition information, distributed information booklets and displayed posters that provided nutrition information and an explanation of the shelf labeling program. In the second and third years of the program (1987-88) the treatment stores only maintained the nutritional shelf labeling. During the entire period, the 12 control stores provided shelf labels displaying only unit and item price information and did not provide any additional nutrition information.

Monthly scanner-obtained sales, price and promotional data were collected at the product level (approximately 11,600 products from over 100 food categories) for all participating stores during the entire time frame of the experiment. Relevant data were collected for all products marketed during the time frame of the experiment, including products introduced during the time frame of the experiment. This is important because the marketing and development of 'healthy' products gained impetus during the late 80s (see Freidman 1995; Frazao and Allshouse 1996; Hickman et al 1993).

Measuring the behavioral effects of a labeling policy change is problematic because it may take months or years before some consumers notice or incorporate the new information in their consumption decisions (see: Levy and Stokes 1987; Levy et al 1985). During the relevant time period there may be changes in other exogenous variables which can confound the measurement of demand effects due to a particular labeling policy. Given the Stop & Shop data are from a controlled 'experiment', comparing demand shifts across treatment and control markets controls for non-label-related changes in demand. As a result, changes in market behavior due to the particular labeling policy can be directly measured between stores having the nutrition labeling policy and those not having the policy.

Empirical Model

To develop an empirical model that allows use of the Stop & Shop data, we begin by defining

$$\Phi(P, a(S; \chi), \Omega; \varphi) = \alpha_0 + \Sigma_i\alpha_{ihmt}\log P_{imt} + (1/2)\,\Sigma_i\Sigma_j\gamma_{ij}\log P_{imt}\log P_{jmt},$$

and

$$\alpha_{ihmt} = \{\xi_i + \tau_i T_t + \phi_{1i}L_{mt} + \phi_{2i}(L_{mt}T_t) + \eta_{1i}E_h + \eta_{2i}(L_{mt}E_h) + \omega_{1i}A_h + \omega_{2i}(L_{mt}A_h) + \theta_{1i}S_t + \theta_{2i}W_t\},$$

where subscripts i and j denote goods, t denotes time, m denotes store and h denotes household; T_t is a time trend, L_{mt}, used as an intercept shifter, is equal to one in treatment stores after the labeling program is implemented, zero otherwise; $(L_{mt}\,T_t)$, is included to measure time dependent label effects[2]; E_h denotes the average number of years of education for the adult shopper in the household[3]; $(L_{mt}\,E_h)$, a label-education interaction term, is included to measure any differential effect of the label across households with different levels of education; A_h denotes the average age of the adult shopper in the household; $(L_{mt}\,A_h)$, a label-age interaction term, is included to measure any dif-

[2] The specification of the label variable implies that the effect of the label is monotonically increasing (or decreasing). Functional forms that allowed the label to have a non-monotonic effect were considered, however, the specification above allowed for the best fit of the model.

[3] Socio-demographic data for individuals who shopped at the stores were provided by Stop & Shop (the provided data were aggregated at the store level). Education and age are included in the demand system because results consistently indicate that these variables are important in explaining diet-disease awareness (Mathios 1996).

ferential effect of the label across age. S_t and W_t represent seasonal indicator variables, S_t is equal to one in the summer months (June July and August), zero otherwise; and W_t is equal to one during the winter months (December, January and February), zero otherwise; P_{jmt} is the price of good j sold in store m at time t.

The above specification provides estimable share equations aggregated to the store level

(5) $W_{imt} = \xi_i + \tau_i T_t + \phi_{1i} L_{mt} + \phi_{2i}(L_{mt} T_t) + \eta_{1i} E_m + \eta_{2i} (L_{mt} E_m) + \omega_{1i} A_m + \omega_{2i} (L_{mt} A_m) + \theta_{1i} S_t + \theta_{2i} W_t + \Sigma_j \gamma_{ij} \log P_{jmt} + \beta_i \log(Y_{mt}/P^*_t)$

where W_{imt} is the share of aggregate expenditure on good i in the aggregate budget of all households frequenting store m, $E_m = \Sigma_h\{Y_{ht} E_h/\Sigma_h Y_{ht}\}$, $A_m = \Sigma_h\{Y_{ht} A_h/\Sigma_h Y_{ht}\}$, and $\log Y_m = \Sigma_h\{Y_{ht} \log (Y_{ht}/k_h)/\Sigma_h Y_{ht}\}$. Note that the summation, Σ_h, is over households frequenting only a particular store, not over all households. The estimated average household size, K_m, included in the Stop & Shop data, is used to deflate income.

Equation (5), with some simplifying assumptions, allows us to use the Stop & Shop data for the estimation. The Stop & Shop data includes mean values for education and age. However, the expressions for E_m and A_m are not mean values unless one assumes that either: 1) the probability of a shopper's education or age is equal to $Y_{ht} /\Sigma_h Y_{ht}$ for all h, or 2) the value of education or age is the same value for every household in market m. Neither of these assumptions is entirely satisfactory. However, these are the only measures of education and age available in the data.

The general expression for each equation in the demand system is as in (5) except that the prices for the goods of interest are share-weighted prices, E_m and A_m are represented by their respective means and the dependent variable for the equation representing all other goods is $\{\Upsilon_{mt} -\Sigma_j(P_{jmt} * X_{jmt})\}/\Upsilon_{mt}$, where Υ_{mt} is equal to the calculated aggregate income for each store/time period.

The non-linear system of equations is estimated by using iterative seemingly unrelated regression. During estimation, the adding-up ($\Sigma_j \xi_j = 1$; $\Sigma_j \phi_{1j} = 0$; $\Sigma_j \phi_{2j} = 0$; $\Sigma_j \eta_{1j} = 0$; $\Sigma_j \eta_{2j} = 0$; $\Sigma_j \omega_{1j} = 0$; $\Sigma_j \omega_{2j} = 0$; $\Sigma_j \theta_{1i} = 0$; $\Sigma_j \theta_{2i}= 0$; $\Sigma_j \gamma_{ij} = 0$; $\Sigma_j \beta_j = 0$), homogeneity ($\Sigma_i \gamma_{ij} = 0$) and symmetry ($\gamma_{ij} = \gamma_{ji}$) conditions are imposed on the system.[4] Given the data are time-series, potential autocorrelation is corrected by following the procedures outlined by Berndt and Savin (1975) and Piggott et al (1996).

The analysis of the impact of the nutrition labeling program focuses on several categories of products that vary in terms of the size/composition of the choice set, and in terms of the nutrition information being provided (Table 1). Separate demand systems are estimated for six different food categories (milk, cream cheese, refried beans, peanut butter, mayonnaise and salad dressing). Each demand system is composed of three equations, one equation for the 'healthy' goods in the food category, one for the 'unhealthy' goods in the category and one equation for spending on all other goods. For the analysis, 'healthy' products are those that qualify for one of the nutrition shelf labels (e.g., 'healthy' refried beans are those that qualify for a low-fat label); 'unhealthy' products are those that do not qualify for one of the shelf labels.

Except for salad dressing (where multiple flavors of salad dressing are represented in each equation), the products represented by the 'healthy' and unhealthy' demand equations are relatively homogeneous across products within a category. Note that before implementation of the labeling program both 'healthy' and 'unhealthy' goods are unlabeled. 'Healthy' goods are labeled (unlabeled) in treatment (control) stores after implementation of the labeling program; 'unhealthy' goods are not labeled in either the treatment or control stores.

Results

This section begins with a brief presentation of the non-label parameters followed by a discussion of the label-related parameters. Table 2 summarizes the sign and significance of the coefficients across all equations.[5] Interpretation of the label coefficients is complicated by the presence of the interaction terms. To derive the net impact of the labeling program on market behavior, both the signs and the magnitudes of the main-effect

[4] All the models were estimated both with and without the restrictions imposed. Using the joint test procedure of Gallant (1987) no significant differences between the restricted and unrestricted models were found.

[5] Parameter estimates are available from the author.

coefficients (label dummy) and the label interaction coefficients (label-trend, label-education and label-age) must be taken into account. To make results clear, the estimated equations are used to illustrate the changes in market behavior induced by the labeling program (Figures 2-7).

Table 1. Characteristics of the food categories used in the analyses.

Product Category	Labeling Program	Number of "healthy" Products in Category	Number of "unhealthy" Products in Category
Milk	Fat	14	21
Cream Cheese	Sodium	5	7
Refried Beans	Fat	1	5
Peanut Butter	Sodium	14	25
Mayonnaise	Cholesterol	9	17
Salad Dressing	Fat, Cholesterol, and Calories	54	184

Table 2. Summary of significant parameters from the estimated AIDS models, H = 'healthy' equation, U = 'unhealthy' equation.

	Milk		Cream Cheese		Refried Beans		Peanut Butter		Mayonnaise		Salad Dressing	
	H	U	H	U	H	U	H	U	H	U	H	U
Intercept	+	+		-	+	+	+	+	+	+	+	-
$\log(Y_{mt}/P^*_t)$		–	–	+	–	–	–					–
Time	+	–	+	+	+	⊕	⊖	–	⊖	–	–	+
Label Dummy	+		+	+	+	⊕	+		–	+	–	+
Label* Time	⊕	+	–	⊖	+			+	⊖	+	+	–
Education	+			+	+	⊕	+	–	+		–	+
Label* Education	–			–			–	+		+	+	–
Age	–	+		+	–		+	⊕	–	+	+	+
Label* Age			–	⊖	–	⊖	⊖	–		–	+	–
Summer	–	–	–	+		+	–		+	+	+	+
Winter	+	+				+			–			+
Own Price	–	–	–	–			–		–		–	
Cross Price	+	+			+	+	+	+	+	+		
R^2	.66	.41	.52	.48	.38	.42	.59	.39	.73	.48	.64	.56

A - indicates a negative coefficient and a + indicates a positive coefficient. If coefficients in companion equations have the same sign and are not otherwise indicated, then the size of the coefficients are not significantly different from each other.

A ⊖ indicates that the coefficient is negative and larger (more negative) than the negative coefficient in the companion equation.

A ⊕ indicates that the coefficient is positive and larger than the positive coefficient in the companion equation.
A blank indicates the coefficient was not significant at the 10 percent level.

Except for the 'unhealthy' cream cheese equation, all the significant income coefficients suggest that the share of income devoted to purchases of these food categories decreases with increases in income, i.e., that these food items are not luxury goods. The coefficients on the seasonal variables indicate that milk share decreases (increases) during the summer (winter). Conversely, mayonnaise and salad dressing shares increase during the summer months. All the own-price coefficients indicate that an increase in own-price leads to a decrease in share; all the cross-price coefficients indicate 'healthy' and 'unhealthy' products are substitute goods.

The time trend coefficients in the milk equations indicate that consumers were shifting their purchases from 'unhealthy' milk to 'healthy' milk even without the labeling program in place. The time trend coefficients in both the cream cheese and refried bean equations indicate overall growth in both markets, although sales of 'unhealthy' refried beans were increasing relatively more than sales of 'healthy' refried beans. The time trend coefficients in both the peanut butter and mayonnaise equations indicate that sales of these products were decreasing during the time period. Without the labeling program in place, shares of 'healthy' peanut butter and 'healthy' mayonnaise were decreasing relatively more rapidly than their corresponding 'unhealthy' shares. The time trend coefficients in the salad dressing equations indicate decreased (increased) expenditures on (un)healthy salad dressings. Presumably, these shifts in consumption are due to changes in consumers' health preferences (i.e., consumers' value for health changed) or consumers' became more aware of diet-disease issues. Ippolito and Mathios (1996) indicate that consumers in the United States became more aware of diet-disease links during the mid-to-late 80s.

As indicated by the education coefficients, shares of 'healthy' milk, peanut butter and mayonnaise were greater among more educated households whereas shares of 'unhealthy' cream cheese, refried beans and salad dressing were greater among these households. Except for salad dressing, the age coefficients indicate that shares of 'healthy' products were lower among older households; there was no differential effect of age on the shares of 'healthy' and 'unhealthy' salad dressing.

In the milk equation the net effect of the label-related coefficients indicate that the labeling program (which placed low-fat labels on the 'healthy' milk products along with a related information campaign) initially increased the 'healthy' share among all consumers and that these increases continued to increase with time (Figure 2). The time-dependent increases in 'healthy' share were occurring while the labeling program was much reduced in scope. In the cream cheese equations the net effect of the label-related coefficients is that the labeling program increased the share of 'healthy' cream cheese and that these increases remained stable with time (Figure 3). For refried beans, the net effect is that the presence of the labeling program increased the 'healthy' share and that the initial increase in the 'healthy' refried bean share continued to increase with time (Figure 4).

In the peanut butter equations the results indicate that the labeling program increased the 'healthy' share and that initial gains made in the 'healthy' share eroded with time (Figure 5). Although the share of 'healthy' peanut butter is declining through time, the labeling program countered this decrease so that by the end of 1988 'healthy' peanut butter's share with the labeling program was roughly equivalent to what it was at the beginning of 1985 (a three percent decline). In contrast, without the labeling program the estimated 'healthy' share would have decreased by approximately 17.6 percent during the same time period. In the mayonnaise and salad dressing equations the net effect is that the labeling program *decreased* 'healthy' share and that these initial decreases in 'healthy' share became smaller with time (Figures 6 and 7, respectively).

Figure 2. Estimated share of 'healthy' milk with and without labeling.

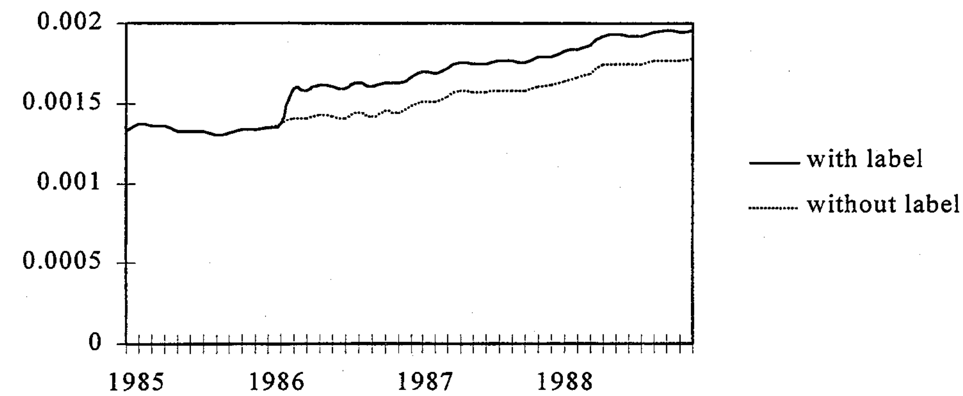


Figure 3. Estimated share of 'healthy' cream cheese with and without labeling.

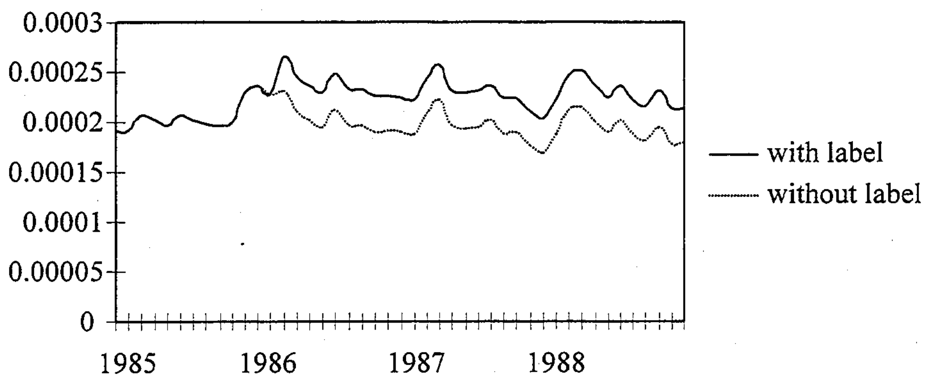


Figure 4. Estimated share of 'healthy' refried beans with and without labeling.

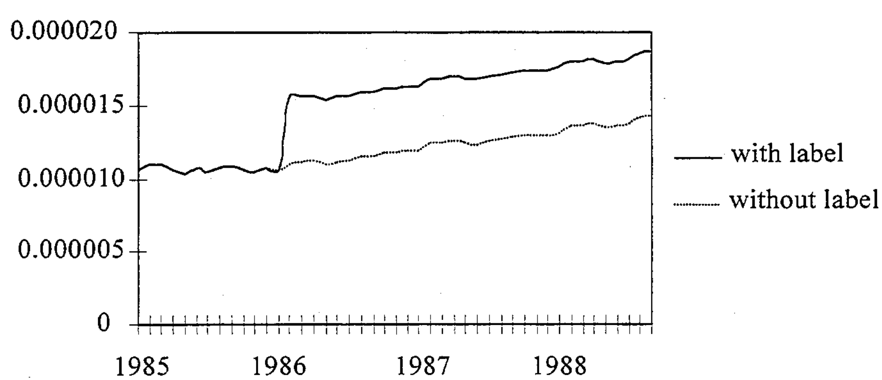


Figure 5. Estimated share of 'healthy' peanut butter with and without labeling.

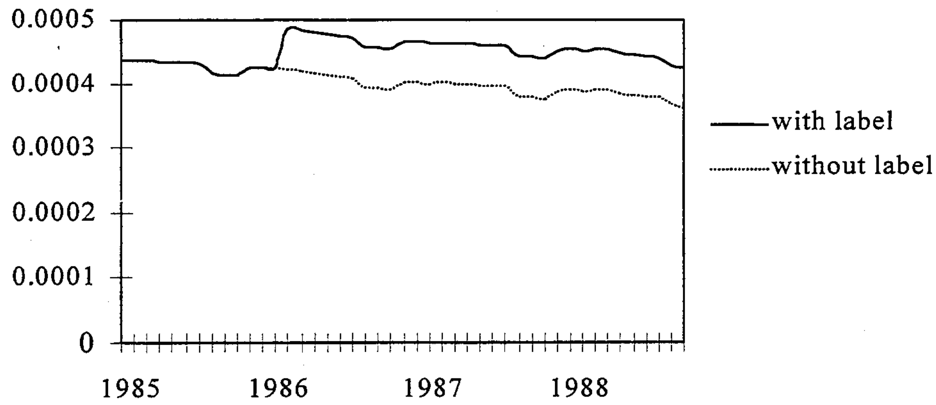


Figure 6. Estimated share of 'healthy' mayonnaise with and without labeling.

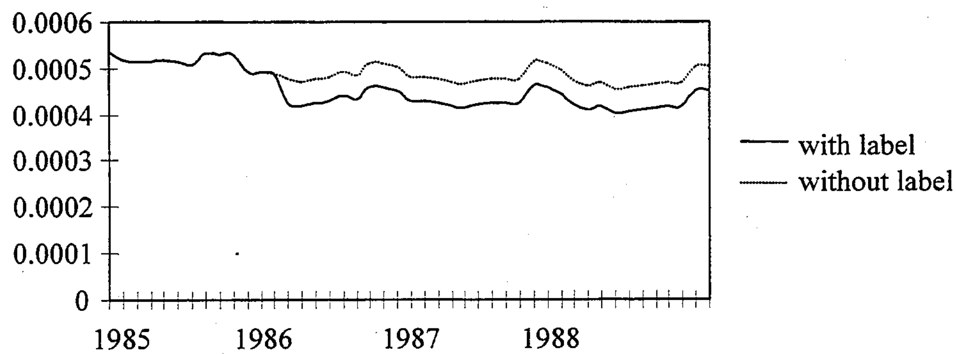
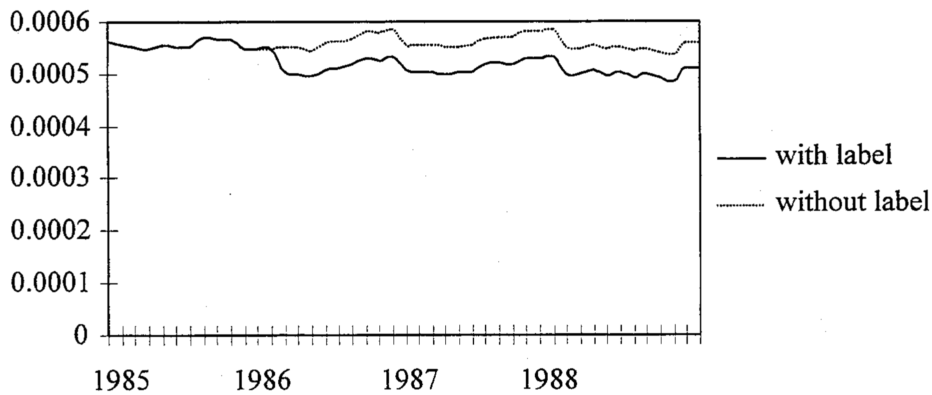


Figure 7. Estimated share of 'healthy' salad dressing with and without labeling.



Implications

The results suggest that labeling of food products with respect to their nutritional characteristics along with an information campaign to educate consumers can significantly affect consumer behavior. The main effect of the labeling program occurred relatively quickly. These relatively large initial impacts may not be solely due to the presence of nutritional labels but may be partially attributed to the ancillary activities occurring as part of the initial labeling program. Other market-based research on the effects of food labeling demonstrates that the impact of a labeling program may not be felt immediately (Levy et al., 1985).

Although relatively small, the label-trend terms have a significant impact in all but the cream cheese equations. There may be two possible reasons for this temporal effect. First, while some consumers may have immediately noticed the label change, as suggested by the significance of the label-dummy coefficients, other consumers may not have noticed. Second, some consumers may have noticed the new labels but did not believe the label information. Diffusion of awareness about the nutritional labels and increases in perceived believability may explain the label-trend interaction terms.

The behavioral changes observed here (relatively large initial impacts that are generally maintained across time) are somewhat different than observed in other research studying the market effects of health information provided by the news media. In those studies, the release of health-related information caused relatively large initial changes in consumer behavior but they generally eroded with time. Presumably, the constancy of the labeling program helped maintain the initial changes in consumer behavior.

Importantly, the results provide some evidence that consumers act as if they have nutrient or health risk budgets (e.g., a fat budgetary constraint). It is not simply the case that providing health-related information leads to increased consumption of 'healthy' foods across all food categories. In fact, providing nutrient information on food products may have two effects. First, consumers may reduce their net intake of 'unhealthy' nutrients by increasing their purchases of 'healthy' products (i.e., something analogous to an 'income effect'). Second, consumers may switch consumption away from 'unhealthy' products in those food categories where differences in other quality characteristics (e.g., taste) are relatively small between the more and less 'healthy' products, and switch consumption toward 'unhealthy' products in food categories where differences in other quality characteristics may be relatively large between the more and less 'healthy' products (i.e., a 'substitution effect').

Interestingly, Jensen et al. (1996) indicate a similar trade-off between nutrition and taste in explaining differences in nutrition label use across products. If this substitution effect is large then overall consumption of 'healthy' products (and the resulting health risk) may be unchanged or relatively small. In this case, providing nutrition information may not create any significant change in health risk. Importantly, if individuals maintain nutrient budgets, then, unless substitution effects are correctly identified, the current method of valuing nutrition label programs (the cost of avoided illness approach) may overestimate the social benefits of providing this type of information.[6]

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[6] The cost of avoided illness approach begins by estimating shifts in demand for a food product due to providing information. These demand shifts are used to estimate changes in nutrient intakes which are then used to calculate changes in disease rates. Social benefits (medical cost savings and dollar value of life years gained) are then calculated based on these decreased disease rates.

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