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A FRAMEWORK FOR ANALYZING THE EFFECTS OF HEALTH INFORMATION ON PRODUCT DEMAND WITH AN APPLICATION TO SHELL EGG CONSUMPTION

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Abstract

This paper presents a theoretical framework to assess the effect of health information on the demand for an affected product. This framework is applied to the shell egg market. The empirical evidence suggests that health information linking diet to heart disease is responsible for reducing per capita shell egg consumption by 10 to 11 eggs per quarter (a 14% reduction).

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A Framework for Analyzing the Effects of Health Information on Product Demand with an Application to Shell Egg Consumption

Since the late 1960's there has been an increase in the amount of available health information concerning either the harmful or beneficial effects of consuming products ranging from red meats to condoms. This increase in available health information naturally leads to three related questions. First, does new health information about a product result in a detectable structural change in the demand for that product? Second, how great is the decline (increase) in the demand for a product due to the new information? Finally, what is the time path of the information's effect on demand?

Several articles have recently appeared in the literature (Chalfant and Alston (1986); Chavas (1983); and Pope, Green, and Eales (1980)) that test for structural change in the demand functions of numerous products (most particularly red meats). Many authors (Chavas (1983)) argue that the observed structural change for many of these products is attributable to both increased health concern on the part of consumers, and to social and demographic changes in the population. However, no effort has been made in the existing literature to separate out the effect of health information from the social and demographic changes that may affect the demand for certain products.

This paper presents a framework which allows health information effects to be separated (if there is a sufficiently long time series available) from other factors that result in structural change in the demand for a given good. We are able to separate health information effects from other effects due to differences in the time path of health information effects vis a vis social and demographic effects. We would expect structural change in the demand for a product due to social and demographic causes to occur gradually over the entire period of observation and beyond. In the case of new health information (if we have data that include observations before and after the release of the information) we would expect a more abrupt structural change due to the information's effect during the period of observation. Further, the full effect of the health information on product demand may also occur within the observation period.

The methodology developed in this paper to analyze the effect of health information on product demand draws on both household production theory (Becker (1965); Stigler and Becker (1977); and LaFrance (1983)) and epidemic theory (Bailey (1975); Bartholomew (1982); and Lekvall and Wahlbin (1973)). This framework allows us to determine when the new information first had an effect on product demand, the ultimate effect of the new information on product demand, and the length of time it takes for the new information to have its full effect.

The remainder of this paper consists of a model that presents the framework for analyzing the effects of health information on product demand, and an empirical application of the framework to shell egg consumption in the United States.

The Model

In the household production model it is assumed that households do not gain utility from the direct consumption of market goods, but through the consumption of "fundamental" goods. Households produce fundamental goods by combining market goods, human capital, and consumer durables with time to produce the goods the consumer desires.

Using the household production framework, LaFrance (1983, pg. 27) has shown that the Marshallian (market) demand function for the i^{th} market good can be written in the form:

$$x_i = x_i(p,m,b) \tag{1}$$

where p is a vector of "full" prices (defined below), m is Becker's (1965) "full" income, and b is a set of parameters that affect the consumer's ability to obtain fundamental goods from market goods.

The household production based market demand function $x_i(\cdot)$ differs from the market demand functions of standard consumer theory in several important ways. First, the household production theory based demand functions are defined not only on prices and income, but also on the characteristics of the good (the goods ability to produce fundamental goods).

Second, $x_i(\cdot)$ is defined on full prices rather than market prices. The full price of a good includes both the actual market price of the good and the value of time associated with using the good in the household production process. Thus, the relative prices of two goods depend on both the relative market prices of the two goods, and the relative time costs associated with using both goods. This implies that (if the vector of actual market prices is p_x and the vector of full prices is p) it is likely p_i/p_j

$\neq p_{xi}/p_{xj}$.

Finally, $x_i(\cdot)$ is defined on full income rather than money income. Full income is defined as $m = y + w'T = y_0 + w'(l_0 + l)$ where y is non-labor income, w is a vector of wage rates, T is a vector of time endowments, l_0 is a vector of labor time, and l is a vector of household production time[1/]. Full income consists of both money income $y = (y_0 + w'l_0)$, and the value of household production time $(w'l)$.

If we assume that each consumer's demand function is in some sense linear (either linear or log linear) in full prices and income, and in a scalar valued function of the characteristic vector, then the demand for the i^{th} good by representative consumer is given by:

$$x_{ij}(p,b,m) = \mu_0 + \varepsilon' p + \eta m + \theta(b) \qquad (2)$$

Empirically estimating the above equation presents a problem since it is a function of full prices and income when only data on actual market prices and money income are available. However, one variable which is frequently available, and which is an important indicator of changes in the value of household production time, is the employment status of the group most likely to be homemakers, women 20 years of age and over[2/].

It is assumed that the use of each unit of a market good entails a fixed time input in the household production process. We further assume that the effect of homemaker entry into the labor force results in a discrete shift in the value of household time. Using these two assumptions allows us to write the full price of good i and full income as:

$$p_i(p_{xi}, L) = p_{xi} + \nu_{1i} + \nu_{2i}L \qquad (3)$$

and

$$m(y, L) = y + \kappa_1 + \kappa_2 L \qquad (4)$$

where p_{xi} is the actual market price of good i, L is an indicator function that takes on the value of 1 if the homemaker is in the labor force and 0 otherwise, and y is the level of both labor and non-labor income.

Substituting equations (3) and (4) into equation (2) allows use to rewrite the Marshallian demand for the i^{th} good by a given consumer as a function of actual market prices and money income of the form:

$$x_i(p_x, y, L, b) = \mu_0 + \varepsilon'(p_x + \nu_1 + \nu_2 L) + \eta(y + \kappa_1 + \kappa_2 L) + \theta(b)$$

$$= \mu_1 + \varepsilon' p_x + \eta y + \omega L + \theta(b) \qquad (5)$$

where $\mu_1 = (\mu_0 + \varepsilon'\nu_1 + \eta\kappa_1)$, and $\omega = (\varepsilon'\nu_2 + \eta\kappa_2)$.

Now suppose that there is an exogenous release of information regarding a subset of the production parameters. As an example of this consider the effect of health information regarding saturarated fat intake and heart disease on peoples' beliefs about the ability of red meats to provide the fundamental good "good health". At some point after its release, a representative consumer receives this new information. We assume that upon receipt of the information the vector of perceived market good characteristics changes from b^0 to b^1. The effect of this information is to change the demand for good i by the consumer from:

$$x^0_i(p_x, y, L, b) = \mu_1 + \varepsilon' p_x + \eta y + \omega L + \theta(b^0)$$

to (6)

$$x^1_i(p_x, y, L, b) = \mu_1 + \varepsilon' p_x + \eta y + \omega L + \theta(b^1)$$

Equation (6) can be rewritten as:

$$x_i(p_x, y, L, I) = \mu + \varepsilon' p_x + \eta y + \omega L + \Delta\theta\, I \qquad (7)$$

where $\mu = \mu_1 + \theta(b^0)$, $\Delta\theta = \theta(b^1) - \theta(b^0)$, and I is an indicator function that takes on the value of one if the consumer has received the information and zero otherwise.

Whether or not a representative consumer has received the information at a given point in time can be viewed as a draw form the binomial distribution $b(1,\pi)$. The parameter π is the percentage of the population that have received the information.

The new information is unlikely to be received by all consumers in the economy instantaneously, instead it will diffuse through the population over time. Thus, the parmeter π is not constant, but varies over time. If the information is released at time t^* and is received by all consumers at time τ, then $\pi(t) = 0$

for $t \leq t^*$, $0 \leq \pi(t) \leq 1$ for $t^* \leq t \leq \tau$, and $\pi(t) = 1$ for $t \geq \tau$. At a given in moment in time, the expected demand for good i by a representative consumer is given by:

$$\begin{aligned} E[x_i(p_x, y, L, t)] &= E[\mu + \varepsilon' p_x + \eta y + \omega L + \Delta\theta I] \\ &= \mu + \varepsilon' p_x + \eta y + \omega L + \Delta\theta E(I) \\ &= \mu + \varepsilon' p_x + \eta y + \omega L + \pi(t)\Delta\theta \qquad (8) \end{aligned}$$

We are now left with the problem of determining $\pi(t)$.

There exists an extensive literature in mathematical sociology (Bartholomew (1982)) dealing with the diffusion of information, news, ideas, and fashions. This literature is strongly related to (and started from) the literature on the diffusion of innovations. The classic articles in the innovation diffusion literature are Griliches (1957); Mansfield (1961); Rodgers (1962); and Lekvall and Wahlbin (1973). The tools that are used to analyze these problems have been borrowed from epidemic theory[3/]. The analysis in this paper is based on the <u>simple epidemic model</u>.

In the simple epidemic model new information is transferred to consumers either via other consumers or via the mass media. Those consumers that have heard the information are known as hearers, thus, $\pi(t)$ gives the percentage of hearers in the population at time t.

If at a given instant in time the percentage of hearers spreading the information to other consumers is β, then the percentage of the population exposed to the information at that moment from other consumers is equal to $\beta\pi(t)$. Further, assume that at a given instant α percent of the population is exposed to the new information from a "source" (a news story, a magazine article, an advertisement, etc.). Thus, the percentage of the population that is exposed to the new information at a given instant in time is equal to $(\alpha + \beta\pi(t))$. The percentage of the population that are exposed to the new information for the first time (the change in the percentage of hearers) is equal to the percentage of the population exposed to the information multiplied by the percentage of the population previously unexposed, or:

$$\dot{\pi} = (\alpha + \beta\pi(t))(1 - \pi(t)) \tag{9}$$

Equation (9) is the well known logistic differential equation. If we impose the initial conditions that $\pi(0) = 0$, and $0 \leq \pi(t) \leq 1$, the solution to (9) is:

$$\pi(t) = \frac{\exp[(\beta + \alpha)t] - 1}{\exp[(\beta + \alpha)t] + \beta/\alpha} \tag{10}$$

In this formulation the parameter α is known as the "intensity of transmission of the source", and β is known as the "intensity of transmision between individuals".

Equation (10) allows the diffusion path to take on a continuum of shapes (Lekvall and Wahlbin (1973)) ranging from a symmetric S-curve (a logistic functon) to a J-curve (a modified exponential function), with asymmetic S-curves falling between these two extremes. The exact shape of the information diffusion path depends upon the values of α and β. As α approaches zero (the effect of communication between consumers dominate source effects) the path becomes a symmetric S-curve. As β approaches zero (information from the source dominates communication between consumers in spreading the information) the path becomes a J-curve.

Unfortunately, it is unlikely that the time t* will be known with perfect certainty. However, using the fact that our expression for $\pi(t)$ is bounded by zero and one, and that $\pi(0)$ is zero allows us to write equation (10) as a single equation (for all t) in which t* becomes a parameter to be estimated of the form:

$$\pi(t) = \frac{\exp[(\beta + \alpha)T] - 1}{\exp[(\beta + \alpha)T] + \beta/\alpha} \tag{11}$$

where $T = \{(t-t^*) + |t-t^*|\}/2$.

At this point we can substitute (11) into (8) to find that the expected demand for good i by a representative consumer at time t is given by:

$$E[x_i(p_x, Y, f, t)] = \mu + \varepsilon' p_x + \eta Y + \omega L + \frac{\exp[(\beta + \alpha)T] - 1}{\exp[(\beta + \alpha)T] + \beta/\alpha} \Delta\theta \tag{12}$$

The parameters of equation (12) (μ, ε, η, ω, α, β, $\Delta\theta$, and t*) can be estimated using non-linear regression techiques[4/]. Estimation of (12) will allow us to assess the level of the effect of the new information on the demand for good i, when the information first began to have an effect on product demand, the length of time before the information has its full effect on product demand, and the time path of the information's effect.

An Application to Shell Egg Demand

Eggs commercially produced in the U.S. are sold on one of two markets: the first (and higher price market) is the shell egg market, the second is the breaking egg market. Shell eggs are the cartoned eggs that consumers are accustomed to buying at the retail level. Breaking eggs are typically sold in either frozen or dried forms to food processors to be used in processed foods or packaged baked goods. Since consumers have more direct control of their consumption of shell vs. breaker eggs, is was believed that studying shell egg demand would be a more direct test of the theoretical framework than looking at total egg demand.

Per capita consumption of shell eggs (see figure 1) has been declining since the mid-1950's. However, the decline had been very gradual until the late 1960's when a very rapid decline in consumption began to occur. Many people both inside and outside the egg industry believe that this rapid decline was caused by the release of medical research that showed a link between dietary cholesterol and saturated fat intake, and blood serum cholesterol levels and heart disease.

In the following sections we use the theoretical framework developed earlier to examine the effect (if any) of health information on shell egg demand. The analysis is based on a quarterly data set for the period extending from the first quarter of 1960 to the fourth quarter of 1985 (a period of 26 years). The first five observations were not used in the estimation since the estimated equations use lags of up to five periods, therefore, the data set consists of 99 observations beginning in the second quarter of 1961. We believe that this data set begins early enough to fully assess any effects caused by the release of the relevant health information. The analysis is carried out on the per capita demand for shell eggs.

<u>The Source of the Information</u>

Evidence that indicated there may exist a link between diet and heart disease first appeared in the nutrition and medical research literature in the late 1950's (Stare (1968)). However, the evidence presented at that time was inconclusive, and thus was not widely reported outside of the bio-medical research community.

In the mid-1960's public health officials became alarmed at the increasing incidence of fatal heart disease among middle-aged men (Brown (1967)). During this period heart disease became the primary cause of death in the United States for the first time. The general public was made aware of the heart disease "epidemic" through magazine articles, such as "I am Joe's Heart" (Ratcliff (1967)), and news stories in the mass media.

The principle focus of the 1967 American Medical Association convention (held in late June of that year) was to find ways of dealing with the increased incidence of heart disease. At the convention evidence from the "National Diet Heart Study" (Brown

(1967)), a Norwegian study conducted by Leren (1966), and an American study by Stamler et. al. (1966) were presented. All three studies conclusively showed a link between dietary intake of saturated fat and cholesterol and blood serum cholesterol levels. These results lead to a consensus in the medical community that there did indeed exist a link between heart disease and diet.

The 1967 AMA convention received relatively complete national media coverage. Reports on the convention appeared in Time, U.S. News and World Report, and Business Week between the last week of the second quarter and the first week of the third quarter of 1967. All three articles reported on the new medical consensus that there existed a causal link between diet and the incidence of heart disease.

Following the 1967 AMA convention numerous articles on the role of diet in lowering the risk of heart disease began to appear both in the professional and popular press. Therefore, we would expect that any structural change in the the demand for shell eggs would begin to appear sometime near (most likely after) the third quarter of 1967.

Model Estimation

The theoretical model developed earlier uses an indicator function to indicate if a consumer is a member of a household where the homemaker is employed outside the home, which is not available. However, we can obtain a proxy variable (the percentage of women 20 years of age and over who are employed outside the home) that reflects changes in both homemaker employment patterns and the value of household production time.

The use of the female employed rate is of particular importance in the case of shell egg demand since cross section studies (Darrah and Hanna (1968); and Henson(1976)) indicate that the majority of eggs are eaten at breakfast. Since eggs require more preparation time than most other frequently eaten breakfast foods (such as various breads and cold cereal), increases in the female employment rate should increase the "full" price of shell eggs relative to these other foods. Further, the cross section studies indicate that the second largest use for shell eggs is in home baking, which is likely to decline as female employment rates increase.

After testing the prices of beef, chicken, pork, other meats (cold cuts, frankfurters, and lamb), and bakery and cereal products, the prices of other meats (an expected substitute) and pork (an expected compliment) were chosen as the relevant cross price effects. We were somewhat surprised that the price of bakery and cereal products was not a relevant variable in explaining shell egg demand since cross section studies indicate that these products are the most common substitutes for eggs at breakfast. However, differences in the relative time costs of preparing bakery and cereal products instead of eggs may matter much more than the relative market prices for these goods.

Examination of figure 1 reveals a strong seasonality in egg consumption with egg consumption higher in the first and fourth calendar quarters than in the second and third calender quarters. To account for this seasonality quarterly dummy variables were used.

The estimated per capita demand for shell eggs is of the form:

$$x = \mu + \delta_1 q_1 + \delta_2 q_2 + \delta_3 q_3 + \varepsilon_e p_e + \varepsilon_p p_p + \varepsilon_o p_o + \eta y + \omega L + \frac{\exp[(\beta + \alpha)T] - 1}{\exp[(\beta + \alpha)T] + \beta/\alpha} \Delta\theta \qquad (15)$$

where $T = \{(t-t^*) + |t-t^*|\}/2$, μ is the intercept term, $q_{1,2,3}$ are dummy variables corresponding to the first, second, and third calendar quarters respectively, $p_{e,p,o}$ are the prices of grade "A" large eggs, pork, and other meats respectively, y is per capita disposable income, L is the percentage of women over age 20 who are employed, t is a time trend variable which takes the value one for the first quarter of 1960 and increments by one from 60/1 on, and

μ, $\delta_{1,2,3}$, $\varepsilon_{e,p,o}$, η, ω, α, β, $\Delta\theta$, and t^* are the parameters to be estimated. All prices and income were deflated by the consumer price index for all wage earners and clerical workers (CPI-W).

When t^* is endogenously determined the model no longer has continuous first derivatives with respect to all the estimated parameters. Thus, standard gradient based non-linear estimation routines will no longer work. Therefore, the estimation must be carried out using either derivative free non-linear estimation routines, or by performing a grid search over values of t^* and using gradient based methods to estimate the remaining parameters. In this case a grid search method was employed to estimate the model parameters. In the estimation t^* was allowed to range from -17.0 (placing the starting time of the process in the first quarter of 1955) to 57.0 (placing the starting time in the first quarter of 1975).

To avoid simultaneous equation bias with respect to the determination of shell egg price and quantity, Amemiya's (1974) nonlinear two-stage least squares was chosen as the estimation procedure. The structural per capita supply of shell eggs was specified as a "general equilibrium" (Rausser and Just (1982)) equation. The form of the supply equation (making use of the lag operator $L(\cdot)$) is:

$$x = \xi + \gamma_1 p_e + \gamma_2 L(p_e) + \gamma_3 L^2(p_e) + \gamma_4 L^3(p_e) + \lambda_1 p_{fwl} + \lambda_2 L(p_{fwl}) +$$
$$\lambda_3 L^2(p_{fwl}) + \lambda_4 L^3(p_{fwl}) + \lambda_5 L^4(p_{fwl}) + \lambda_6 L^5(p_{fwl}) + \phi_1 p_{fwt}{}^2 +$$
$$\phi_2 L(p_{fwt}{}^2) + \phi_3 L^2(p_{fwt}{}^2) + \Psi_1 p_{fwt} + \Psi_2 L(p_{fwt}) + \Psi_3 L^2(p_{fwt}) +$$
$$\iota_1 p_f + \iota_2 L(p_f) + \iota_3 L^2(p_f) + \iota_4 L^3(p_f) + \iota_5 L^4(p_f) + \iota_6 L^5(p_f) +$$
$$\upsilon_1 p_c + \upsilon_2 L(p_c) + \upsilon_3 L^2(p_c) + \upsilon_4 L^3(p_c) + \upsilon_5 L^4(p_c) + \upsilon_6 L^5(p_c) +$$
$$\zeta_1 q_1 + \zeta_2 q_2 + \zeta_3 q_3 + \varphi \log(t) \qquad (16)$$

where p_e is as before, p_{fwl} is the wholesale price of frozen whole eggs, p_{fwt} is the wholesale price of frozen egg whites, p_f is the price of layer feed (a mixture of 85% corn and 15% soybean meal), p_c is the price of egg-type pullet chicks, $q_{1,2,3}$ and t are as above, and ξ, $\gamma_{1,2,3,4}$, $\lambda_{1,2,3,4,5,6}$, $\phi_{1,2,3}$, $\Psi_{1,2,3}$, $\iota_{1,2,3,4,5,6}$, $\upsilon_{1,2,3,4,5,6}$, $\zeta_{1,2,3}$, φ, are the parameters of the model. All prices (except p_e which is the same as in the demand equation) were deflated by the producer price index for all products.

The structural supply equation was not estimated, but the exogenous variables of the supply equation as well as the exogenous variables of the demand equation were used as instruments in the nonlinear two-stage estimation of the structural demand equation.

The estimated model was tested for first through fourth order autocorrelation by estimating the model with these corrections included. The hypotheses that the model displayed both first and second order autocorrelation could not be rejected using the standard F-test at the 5% level. The hypotheses that the model displayed third and fourth order autocorrelation were rejected, and these corrections were dropped from the final model.

Since a grid search was used to estimate t*, the asymptotic t-values reported by standard econometrics packages (in this case TSP version 4.0) are incorrect because the estimated covariance matrix does not take into account the effect of estimating t*. In an effort to obtain an estimate of the true covariance matrix, the estimated model was bootstapped (Efron (1982)).

In the bootstrap the original estimated model is used to create a bootstrap data set (which contains the same number of observations as the original data set) where each observation is given by:

$$y_i^* = g_i(\hat{\Theta}) + \varepsilon_i^* \qquad (17)$$

where ε_i^* is drawn with replacement from the error terms of the original model. The model is then re-estimated using the bootstrap data set for the dependent variable to determine the bootstrap parameters $\hat{\Theta}^*$. The process of selecting a bootstrap data set and re-estimating the model is repeated a large number B of times (in our case 25 times) resulting in the bootstrap replications $\hat{\Theta}^{*1}$, $\hat{\Theta}^{*2}, \ldots, \hat{\Theta}^{*B}$. An estimate of $\hat{\Theta}$'s covariance matrix is given by:

$$COV = (1/B-1)\sum_{b=1}^{B}(\hat{\Theta}^{*b} - \hat{\Theta}^{*})(\hat{\Theta}^{*b} - \hat{\Theta}^{*})' \qquad (18)$$

where $\hat{\Theta}^*$ is the mean vector of the bootstrap replicates.

In general, the statistical results are very encouraging. The fitted values for shell egg consumption (based on the original model) track the actual values exceptionally well (see figure 2), the vast majority of the estimated coefficients (shown in table 1) are significant at or above the 5% level, and all parameters had the expected sign. The low price and income elasticities are in line with recent time series analyses of shell egg demand (Chavas and Johnson (1980); and Henson (1976)). The estimated own (market not full price) price elasticity at the mean is -0.09, the pork cross price elasticity is -0.09, the estimated other meat cross price elasticity is 0.34, and the money income elasticity is -0.1.

Two different hypothesis tests were conducted with respect to the information diffusion term. The first test had as its null hypothesis that health information had no effect on shell egg consumption. This test is equivalent to a test of whether or not

$\Delta\theta$ is equal to zero (a one restriction test). The critical value for the $F_{(1,84)}$ at the 1% level is 6.9463, the calculated test statistic is 38.4043, thus, we can reject the hypothesis that health information has had no effect on shell egg consumption at the 1% level.

The second test had as its null hypothesis that the information diffusion term was a constant. The purpose of the test is to determine whether or not the release of the health information resulted in an abrupt discrete shift in the demand for shell eggs, rather than the effects of the information diffusing over time. This test can be accomplished by putting restrictions on α and β (two restrictions) such that the non-linear term is a constant. The critical value of the $F_{(2,84)}$ at the 1% level is 4.8671, and the calculated test statistic is 16.7383, thus, we can reject the hypothesis that the health information resulted in an instantaneous discrete shift in shell egg demand at the 1% level.

The parameters of the estimated model indicate that the release of information on the links between diet and heart disease ultimately reduced quarterly shell egg consumption by between ten and eleven eggs (10.11 for the original model and 11.10 for the bootstrap model). A drop in quarterly per capita egg consumption of 10.11 eggs represents a 14% decline in egg consumption from 1961 levels.

The estimate of the beginning of the health information's effect on shell egg demand (time t* in the theoretical model) is 38.0, which corresponds to the second quarter of 1969. The original model indicates that 100% percent of the information's effect on shell egg demand was achieved by the fourth quarter of 1980 (roughly eleven years after the information was released). Table 2 contains the estimated percentage of the health information's total effect on shell egg demand each year after the release of the information, and the corresponding reduction in egg consumption. Figure 3 shows the time path of the health informations effect on shell egg consumption, which has the form of an asymmetic S-curve.

The statistical analysis suggests that the release of information regarding the links between diet and heart disease was only one of two major factors that led to the large decline in shell egg consumption. The second factor was the increasing "full" price of eggs caused by changes in the value of household production time due to the increasing number of women over age 20 who took employment outside the home. In 1961 the employed rate for women over age 20 was 35.6%, while in 1985 the employed rate was 51.0%. This 43% increase in the female employed rate resulted in a reduction in shell egg consumption of 7.26 eggs per quarter (a 10% decline in consumption from 1961 levels). Thus, increases in the employed rate of women between 1961 and 1985 had 72% of the effect that the release of the health information had on shell egg consumption.

Conclusion

The effect of health information on the demand for certain products is of interest to public health officials, producer groups, and to public policy makers in general. Previous work that has attempted to analyze structural change in the demand for products possibly affected by the release of health information did not attempt to separate health information effects from other possible causes of structural change. This paper offers a theoretical framework which allows health information effects to be separated from other possible causes of structural change in the demand for a good. This framework draws on both the economic theory of household production and epidemic theory. Within this framework it is possible to estimate the effect of new health information on the demand for a given product, when the information first had an effect on product demand, the time it takes from the release of that information until it achieves its full effect, and the time path of the information's effect on demand.

The theoretical framework was then applied to shell egg demand. Our empirical analysis suggests that the release of health information which showed a link between the incidence of heart disease and diet resulted in a per capita reduction in egg consumption of between 10 and 11 eggs per quarter (a 14% decline in consumption). This information had its first effect on shell egg demand near the second quarter of 1969, while 100% of the reduction in egg consumption occurred by the third quarter of 1978 (eleven years after the information's release).

Footnotes

1/A more complete explanation of full income is found in Becker (1965).

2/This variable is also likely to proxy other social and demographic factors that affect the value of houshold production time such as family composition (the percentage of single parent households), and the percentage of urban vis a vis rural households.

3/The reader can beome familar with the mathematics of epidemic theory by consulting Bailey (1975). Epidemic theory offers several models tha could prove useful in describing the effect of information on economic activity.

4/Making t* endogenous significantly complicates the estimation (as is explained below). Thus, if the researcher has a stong prior as to when the information became available, he or she may want to impose this time on the model.

References

Amemiya, Takeshi. "The Nonlinear Two-Stage Least Squares Estimator" Journal of Econometrics 2 (July 1974): 105-10.

Bailey, Norman T. J. The Mathematical Theory of Infectious Diseases and its Applications, London: Charles Griffen and Company, 1975.

Bartholomew, D. J. Stochastic Models for Social Processes, 3rd Edition. New York: John Wiley and Sons, 1982.

Becker, Gary S. "A Theory of the Allocation of Time." Economic Journal 75 (September 1965): 493-517.

Brown, Helen B. "The National Diet-Heart Study: Implications for Dietitians and Nutritionists." Journal of the American Dietetic Assocation 52 (1967): 279-87.

Chalfant, James A., and Alston, Julian M. "Testing for Taste Change in Red Meats Demand." Department of Agricultural and Resource Economics, Working Paper no. 402. Berkeley: University of California, April 1986.

Chavas, Jean-Paul. "Structural Change in the Demand for Meat." American Journal of Agricultural Economics 65 (Febuary 1983): 148-53.

Chavas, Jean-Paul, and Johnson, Stanley R. "An Econometric Model of the U. S. Egg Industry." Mimeographed. College Station, Texas: Texas A&M University, Department of Agricultural Economics, May 1980.

Darrah, L. B., and Hanna, Ned. "Egg Purchase, Consumption , and Use Patterns." Department of Agricultural Economics, A. E. Res. 251. Ithica, New York: Cornell University, July 1968.

Efron, Bradley. The Jackknife, the Bootstrap and Other Resampling Plans. Philadelphia: Society for Industrial and Applied Mathematics, 1982.

Griliches, Zvi. "Hybrid Corn: An Exploration in the Economics of Technological Change." Econometrica 25 (October 1957): 501-22.

Henson, Willianm L. "Egg Demand Characteristics: Implications for Programs to Modify Consumption Habits." Department of Agricultural Economics and Rural Sociology, A. E. & R. S. 126. State College, Pennsylvania: Pennsylvania State University, October, 1976.

LaFrance, Jeffery T. Economics of Nutrient Content and Consumer Demand for Food. Ph.D. dissertation, University of California, Berkeley. June 1983.

Lekavall, Per, and Wahlbin, Clas. "A Study of Some Assumptions Underlying Innovation Diffusion Functions." Swedish Journal of Economics 75 (December 1973): 362-77.

Leren, Paul. "The Effect of Plasma Cholesterol Lowering Diet in Male Survivors of Myrocardial Infarction: A Controlled Clinical Trial." Acta Medica Scandinavica 180 (1966): Suppl. 466.

Mansfield, Edwin. "Technical Change and the Rate of Imitation." Econometrica 29 (October 1961): 741-65.

Pope, Rulon; Green, Richard; and Eales, Jim. "Testing for Homogeneity and Habit Formation in a Flexable Demand Specification of U. S. Meat Consumption." American Journal of Agricultural Economics 62 (November 1980): 778-84.

Ratcliff, Joan. D. "I am Joe's Heart." Readers Digest 90 (April 1967): 59-62.

Rausser, Gordon C., and Just, Richard E. "Principles of Policy Modeling in Agriculture." In New Directions in Econometric Modeling and Forecasting In U. S. Agriculture. edited by Gordon C. Rausser. New York: North-Holland, 1982.

Rogers, Everett. Diffusion of Innovations. New York: Free Press of Glencoe, 1962.

Stamler, Jeremiah; Berkson, David M.; Levinson, Monte; Lindberg, Howard A.; Mojonnier, Louise; Miller, Wilda A.; Hall, Yolanda; and Andelman, Samuel L. "Coronary Artery Disease: Status of Preventive Efforts." Archives of Environmental Health 13 (September 1966): 322-35.

Stare, Fredrick. "How We Can Reduce the Risk of Heart Attacks." Readers Digest 93 (August 1968): 127-30.

Stigler, George J., and Becker, Gary S. "De Gustibus Non Est Disputandum." American Economic Review 67 (March 1977): 76-90.

Figure 1. Per Capita Shell Egg Consumption

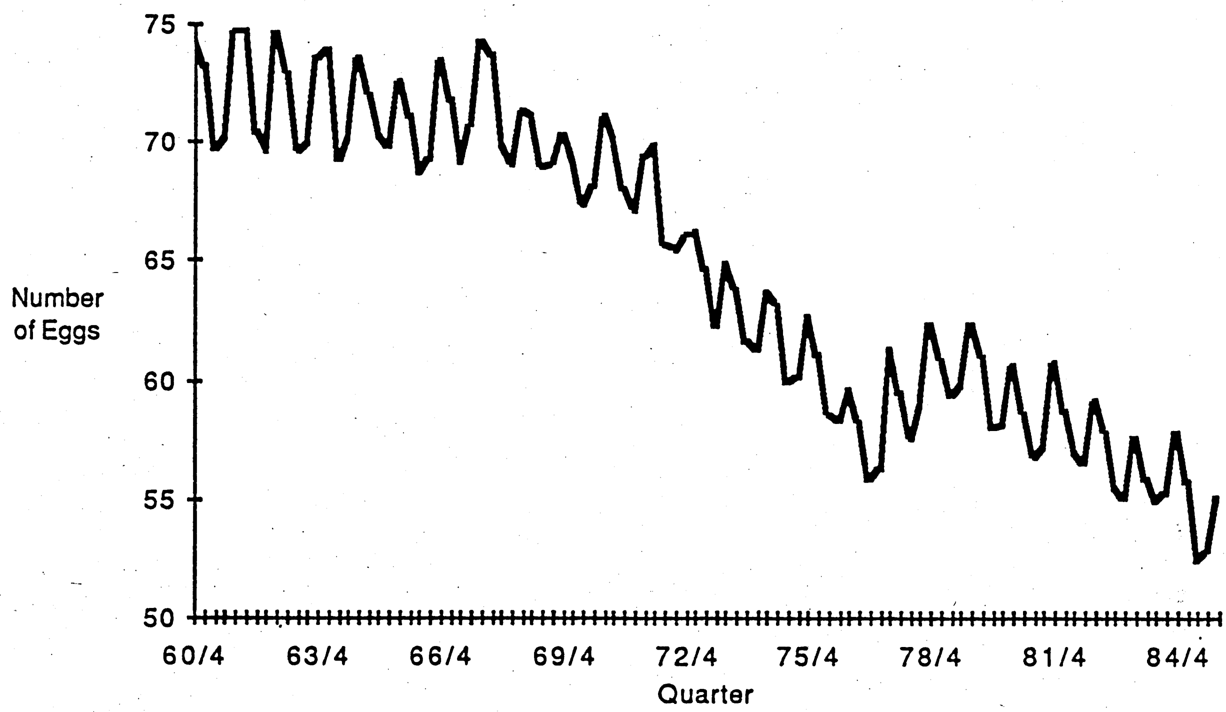

Figure 2. Actual and Fitted Per Capita Shell Egg Consumption

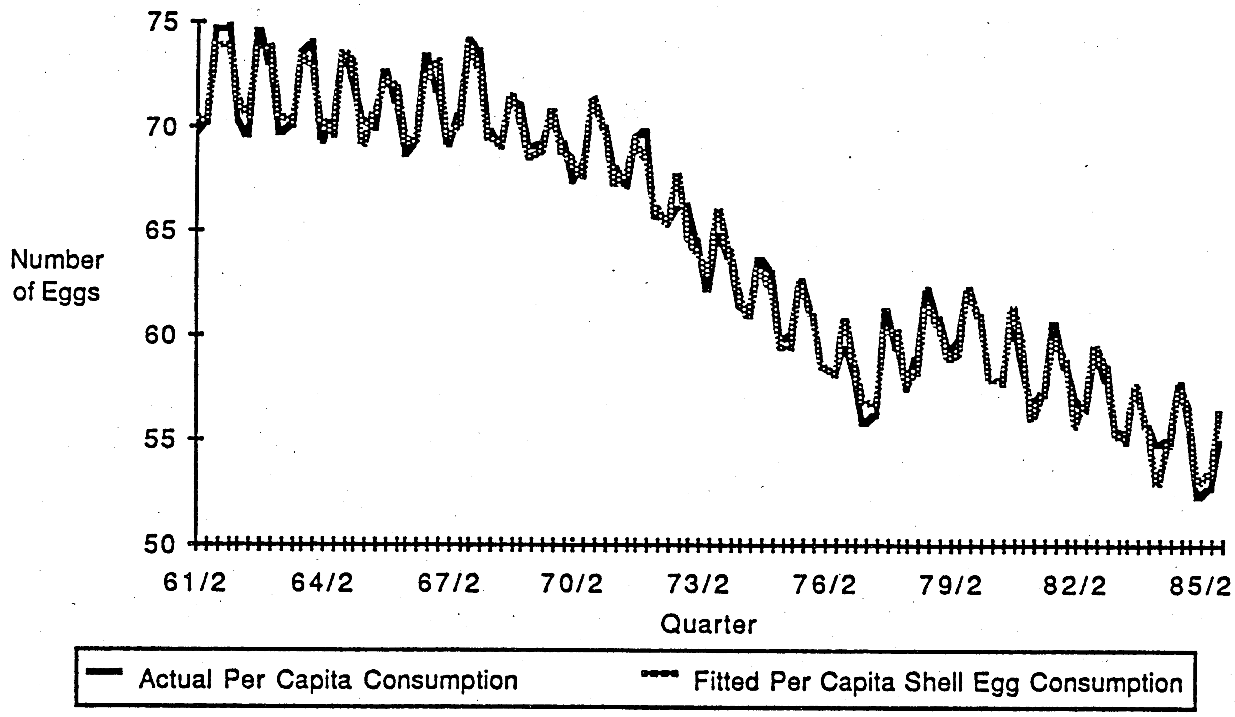

Figure 3. Time Path of the Information's Effect

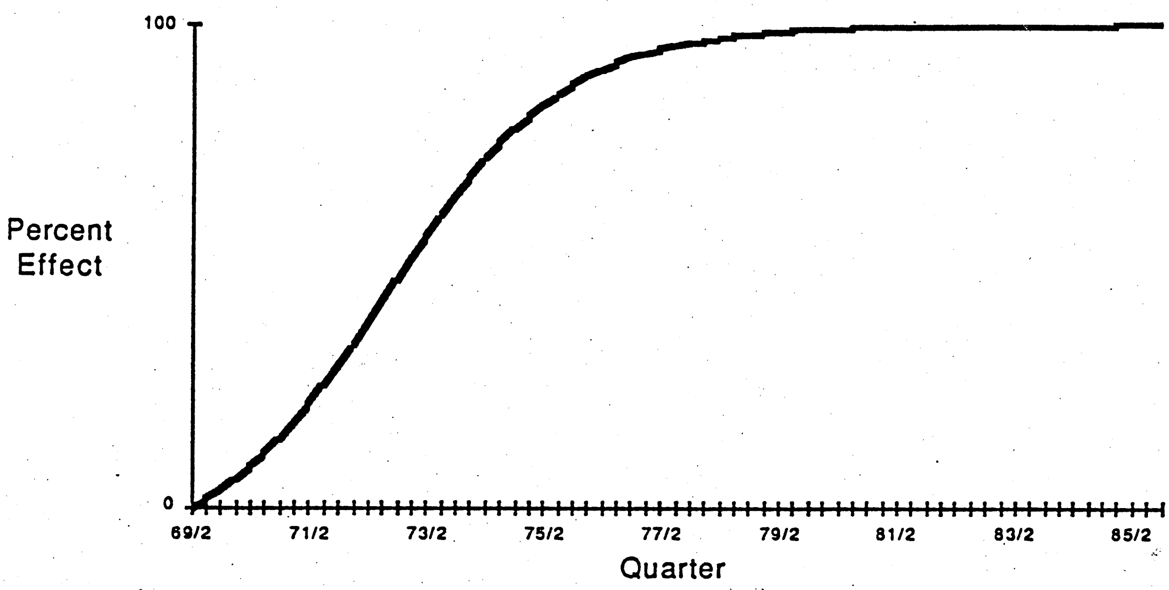

Table 1. Estimated Shell Egg Demand Accounting for Health Information

Parameter	Original Coefficient	Bootstrap Coefficient	Asymptotic t-Value
$\Delta\theta$	-10.11	-11.10*[a]	-8.23[b]
β	0.1489	0.1299**	2.28
α	0.0163	0.0174	1.49
t*	38.0	36.8*	11.49
ε_e	-0.1241	-0.1248*	-4.68
ε_p	-0.0616	-0.0612*	-3.86
ε_o	0.2243	0.2186*	7.80
η	-0.0022	-0.0029**	-2.09
ω	-0.4611	-0.3535**	-2.15
μ	88.22	86.30*	23.68
δ_1	-1.154	-1.095*	-4.77
δ_2	-4.281	-4.217*	-16.23
δ_3	-3.784	-3.686*	-14.28
ρ_1[c]	0.3410	0.3254**	2.09

Table 1., Continued

ρ_2	-0.2275	-0.2189**	-2.13
R^2 [d]		0.9872	
$\bar{R}^2$		0.9852	
$F_{(14,84)}$		489.63	
D. F.		84	
DW		1.99	

[a] A single asterisk indicates statistical significance at the 1% level. Two aterisks indicate statistical significance at the 5% level.

[b] The reported asymptotic t-values are based on the bootstrap estimates of the coefficients and the standard errors.

[c] ρ_1 and ρ_2 are the coefficients for the first and second order autocorreltation corrections.

[d] All summary statistics are based on the original model.

Table 2. The Estimated Effect of the Information on Shell Egg Consumption From 1969 to 1985

Year[a]	Percent of Total Effect	Reduced Quarterly Egg Consumption
1969	2	0.2
1970	11	1.1
1971	25	2.6
1972	43	4.3
1973	61	6.1
1974	75	7.6
1975	86	8.7
1976	92	9.3
1977	96	9.7
1978	98	9.9
1979	99	10.0
1980	99	10.0
1981	100	10.1
1985	100	10.1

[a] Estimate is for the third calander quarter of the year.