# Nutrition and Health: Structural Analysis of Egg Consumption in Canada

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Presentation at the American Agricultural Economics Association Annual Meeting,

August 1-4, 2004 Denver, U.S.A.



Authors acknowledge the financial support of the Cooperative Program in Agricultural Marketing and Business, Department of Rural Economy, University of Alberta

***Introduction***

Egg demand has been and continues to be affected by health information and nutritional concerns. In the late 70's and early 80's, health concerns about cholesterol resulted in a steady decline in per capita shell egg consumption. The egg industry responded through research on nutritional attributes of eggs and development of functional eggs (Omega-3 enhanced eggs, vitamin-enriched eggs, etc.). In both Canada and the U.S. total egg consumption has increased since the mid 1990's (ascribed, in part, to media attention related to the Atkins diet and to the development of functional eggs).

Media coverage focuses on the health and nutritional implications of egg consumption. There is significant coverage in the medical literature of health implications (e.g., cardio-vascular disease) associated with egg consumption. Some of this research is then further publicized through the popular press. At the same time primary producers (through generic advertising) and processing firms (through brand advertising) are significant players in the mainstream media. Egg substitute products are advertised as well. There are a myriad of media forces affecting overall egg consumption figures throughout North America.

There are important implications for industry about how consumers respond to the different media influences. This research highlights whether there are trade-offs associated with the different types of information sources. For example, one of the potential benefits received from consuming Omega -3 fortified eggs is that the Omega-3 fatty acids can lower risk factors for heart disease, such as high blood pressure and high fat levels in the blood. On the other hand, consumers may underestimate this benefit if there is intensive media coverage of the egg-cholesterol link in Canada. Advertising impacts may be greater or smaller depending upon the media coverage of other egg related issues. Industry responses such as advertising content can exacerbate or ameliorate the impact of other media coverage. Increased understanding of the consumer responses can improve the efficacy of the advertising efforts.

Eggs are consumed in a number of different ways. Eggs in the shell are purchased by consumers in grocery stores, and used at home as ingredients in egg main dishes or other products (e.g., cakes, pancakes, etc.). At the same time there is a significant market for breaker eggs, eggs which are used as ingredients in the food processing industry, both to produce direct egg products (frozen or dried egg yolks or whites) and to produce other products (e.g., cakes, cookies, etc.). Ultimately both types of eggs are consumed or disappear. This study differs from earlier studies in that both shell and breaker egg demands are considered simultaneously. Thus, if health concerns induce consumers to avoid egg yolks and they purchase processed egg products rather than raw eggs that substitution can be considered in the modeling exercise.

This study is unique in that the impacts of functional product development and egg-cholesterol media influences on consumers' preferences are investigated using both nonparametric and parametric demand analyses.

***Objective***

The objectives of the paper are (i) to test whether there is a structural change in the egg demand of Canadian consumers due to egg-cholesterol information and the development of functional egg products using a nonparametric approach; (ii) to econometrically scrutinize the impact of functional egg introduction into the market, popular press egg-cholesterol link coverage, health and nutritional issues associated with egg consumption, advertising of eggs and egg substitute products, as well as other economic variables such as prices and income on Canadian egg consumption; and (iii) to further investigate the interactive effects (and/or tradeoff effects) of the different media influences as consumers evaluate consumption decisions in relation to informational variables such as egg nutrition and health information, and advertising.

**Egg Consumption, Advertising and Media Coverage**

Beginning in 1957 Canadian per capita total egg consumption has been declining for the last six decades from as high as 25 dozen per person in 1957 to approximately 15.4 dozen per person in 2002 (Figure 1). Though several factors have contributed to this decline, adverse popularity attributed to cholesterol content and risks of cardiovascular disease ("cholesterolphobia") may have played the major role. Cholesterolphobia, also called the egg-cholesterol-heart disease hypothesis, has been growing since the 1960's because of the probable links between egg cholesterol content and risks of heart disease (McIntosh, 2000). The egg industry has responded through research on nutritional attributes of eggs and development of functional eggs (Omega-3 enhanced eggs, vitamin-enriched eggs, etc.). With this new emphasis on the egg's positive attributes, per capita consumption has slightly risen since the mid 1990's. In many countries, including Canada and the U.S., designer egg production and marketing has also made substantial progress.

Some recent studies claim that the egg-cholesterol-heart disease hypothesis is controversial and unproven (e.g., McIntosh 2000; Harvard Health Letter, 2001). Research clearly indicates that when eggs are consumed as part of a low-fat eating pattern, they are unlikely to alter blood lipid levels. In the early 1990's, as more positive news accompanying functional egg development and nutrition research began to appear in popular press and medical journals, the egg consumption decline levelled off. At the same time some media coverage of heart disease emphasizes the need for lower cholesterol and fat in the diet and eggs are mentioned in this context. The impact of these mixed messages about eggs on consumers is unclear.

The media coverage of the egg-cholesterol diet link was inconsistent over the sample period. Early in the period most articles were negative in this regard. In the latter period 'good news' articles, either about the introduction of enhanced eggs that were a real benefit for consumer health, or articles referring to the fact that basic eggs were not as harmful as previously thought began to predominate. This is portrayed in the net media coverage variable graphed below (i.e., the number of positive articles minus the number of negative articles) (Figure 2). Generic advertising expenditure (that by CEMA and various provincial egg marketing boards) has significantly increased over the same period (Figure 3).

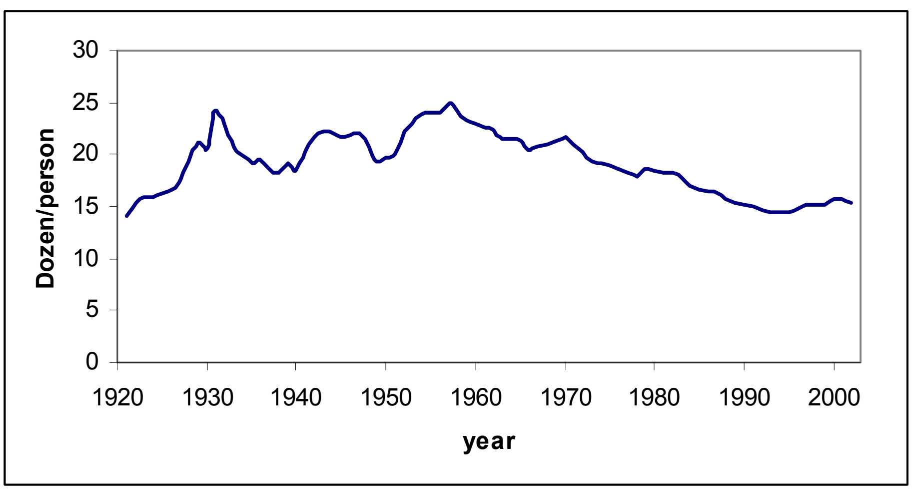


Figure 1: Per capita total (shell plus breaker) egg disappearance in Canada 1921-2002

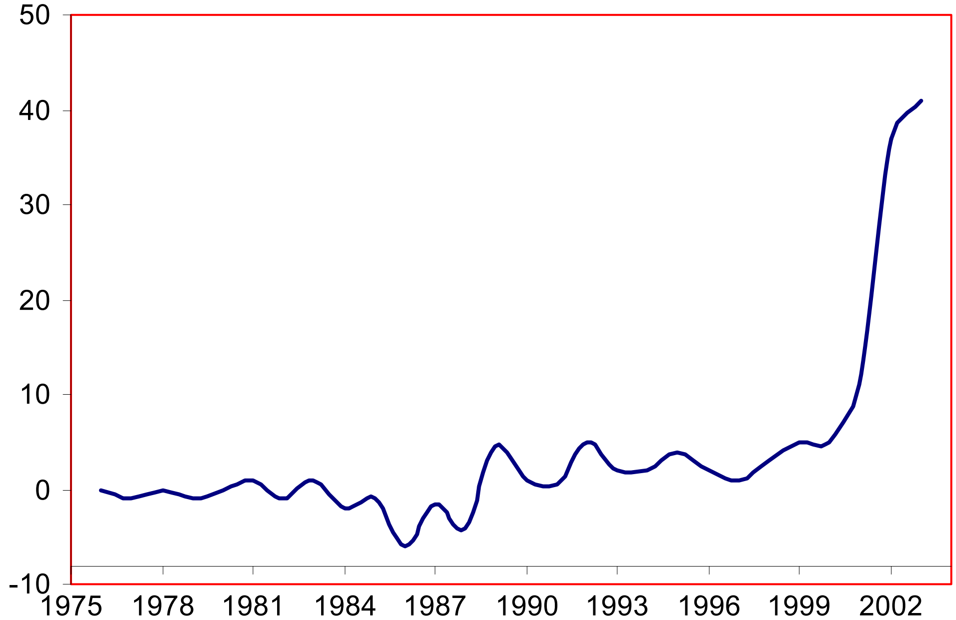


Figure 2: Net Egg-Cholesterol Information Index, 1976 – 2003.

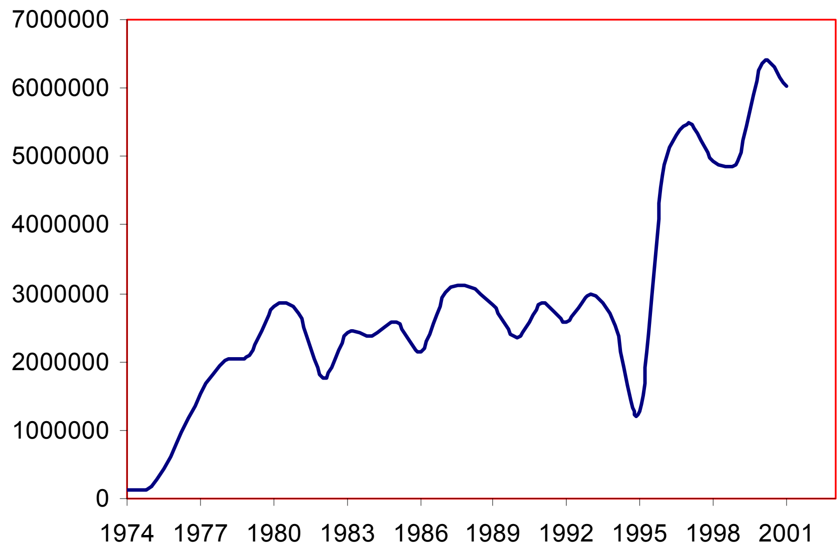


Figure 3: Generic Egg Shell Advertising Expenditure (CAN $), 1974-2001

## Methods

This section outlines demand analysis methods used to investigate structural changes for egg demand. To test the implications of rational behavior and structural changes in egg demand two commonly used approaches are applied: *nonparametric and parametric methods*. The nonparametric approach uses revealed preference theory and focuses on violations of the Weak/Strong/Generalized Axioms in observed data (Varian 1992). The second approach tests parametric restrictions on egg demand using parametric demand specification (Goddard 1988). To combine the advantages of each method, both parametric and nonparametric approaches are adopted in this study.

One of the advantages of the nonparametric approach over the econometric approaches is that specification errors in the econometric demand approaches may account for findings of structural change (Chalfant and Alston 1988; Frechette and Jin 2002). Nonparametric approaches are subject to fewer specification assumptions and therefore offer a better representation of the truth behind structural change. For example, though the econometric demand model provides the statistical significance of a taste change, these tests can be conditional on functional form choice (Goddard et al. 2004). Several empirical studies have investigated taste changes for different products using nonparametric approaches (Chalfant and Alston 1988; Alston and Chalfant 1991; Burton and Young 1991; Jin and Koo 2003). One of the key limitations of the non-parametric test is that effects of non-price determinants of demand (such as advertising intensity) may not be easily incorporated. In the parametric approach, the impact of taste-shifting variables can be introduced by allowing the parameters of the estimated demand function to vary with these variables. Each method is described in detail within the context of the egg market.

***Nonparametric Revealed Preference Test***

The nonparametric demand analyses have been used to test data for consistency with constrained utility maximization. The nonparametric method employs economic logic based on the Axiom of Revealed Preference (Varian 1982; Samuelson 1948; Houthakker 1950; Koo 1963; Richter 1966; Varian 1983; Koo 1971). Under this axiom, consumers' preferences are stable suggesting that variation in observed quantities consumed can be explained by changes in relative prices or expenditures. If choices conform to this axiom then there exists a well-behaved stable preference ordering that could have generated the data and consumers will not switch two bundles of goods that are affordable to them at different points. That is, utility theory is valid for the observed data. If not, the axiom does not hold and the null hypothesis of a well-behaved utility function is rejected, and structural change may be accepted. Thus, this nonparametric test can be implemented by testing for consistency of data with weak (WARP), strong (SARP) and generalized (GARP) axioms of revealed preference (Varian 1992). In this study, the GARP is applied.

**The Revealed Axiom Method**

Suppose we have a set of observations $\{p_t, q_t\}$ for $t = 1,...,T$, where $q_t$ is the observed choice given prices $p_t$. These observations might correspond to the choices made by a representative consumer (individual or aggregate) at different times $1,...T$. According to Varian (1982), the observed consumption data tell us that given prices $p_t$, the bundle $q_t$ was chosen. Suppose $q_s$ is any other feasible bundle[1], $p_t q_t \geq p_t q_s$. The weak axiom of revealed preference (WARP) states that for the consumer to maximize a constrained utility function, a necessary condition is that the consumer prefers $q_t$ to $q_s$ (i.e, $q_t R q_s$) (Samuelson 1948). If bundle qs is also revealed to be preferred to bundle $q_t$ (i.e, $qsRq_t$), then the WARP is violated. Thus, WARP implies that $q_t R q_s \Rightarrow \text{not}(q_s R q_t)$. That is, if $q_t R q_s$ and $q_t$ is not equal to $q_s$, then it is not the case that $q_s R q_t$.

Assume now that P and Q denote, respectively, a T by K matrix of price, and a T by K matrix of quantity. From this it follows that each element of $M_{ts}$ of matrix M=PQ' gives the expenditure, at time t prices, of buying time s's goods. The empirical implementation of the WARP test involves the construction of a matrix Φ with elements $\phi_{st} = p_t q_s / p_t q_t$, where $p_t$ and $q_t$ denote price and quantity vectors at time $t \in [1, T]$[2]. Φ is obtained by dividing every elements of M, $M_{ts}$, by corresponding element, $M_{tt}$ (Alston and Chalfant 1992). Violations of WARP are identified wherever both $\phi_{st}$ and $\phi_{ts}$ are less than one. Any such violation of WARP is interpreted as evidence of a change in preferences between time s and time t. Yet, the absence of WARP violation does not rule out the problem on intransitivity. WARP test is only a necessary condition[3].

WARP is not a sufficient condition, even though the data satisfy WARP, for constrained utility maximization. Thus, in the absence of WARP violations it is necessary to check for consistency of the observed data with GARP (Generalized Axiom of Revealed Preference) (Varian 1992). The Generalized Axiom of Revealed Preference

[1] The bundle is defined as {shell eggs, breaker eggs}.

[2] For T time series observations, there are T*(T-1) pairewise comparisons of consumption bundles that either are consistent with or violate WARP.

[3] Violation of WARP or GARP can occur because of non-optimizing behavior or because of measurement error. To take into account measurement error, Afriat (1967) proposed the following relationship: $q_t$ is *strictly directly revealed preferred* to if an only if $(e.p_t q_t) > p_t q_s$, where e (expenditure similarity) is a value between zero and one.

(GARP) covers the case when, for some price level, there may be more than one level of consumption that maximizes utility.

In the case of GARP, if $p_t q_t > p_t q_s$ and qt is the chosen consumption level, then qt is *strictly directly revealed preferred* to $q_s$. Put differently, GARP states that if $q_t$ is revealed preferred to $q_s$, then $q_t$ cannot be strictly directly revealed preferred to $q_t$. While GARP allows for multiple demanded bundles allowing for flat spots in the indifference curve, WARP requires that there be a unique demand bundle at each budget.

***Parametric Demand Analysis***

As Piggott and Wright (1992) put it: "*The presence or absence of structural change in [egg] demand is critical to marketing decision making. If change is present marketing bodies need to know what underlies the change so that the most appropriate response can be identified. If structural change is not present and changes in consumption can be explained by changes in relative prices…. Getting it right and determining whether structural change has occurred and, if it has, identifying what caused it, is pertinent for industry polices in the future. Getting it wrong could be costly*." (p. 234).

The results from the nonparametric study on structural change will be combined with the parametric approaches using random coefficients on the specified demand relationship. In addition, this approach will provide the significance of the effects of the taste-shifter variables and their interactions with each other. Egg parametric demand analysis has been widely undertaken in Canada and the U.S. (Schmit, Reberte, and Kaiser 1997; Wang, Jensen, and Yen 1996; Yen, Jensen, and Wang 1996; McCutcheon and Goddard 1992; Brown and Schrader 1990; Schmit and Kaiser 1998; Loyns and Lu 1973; Kulshreshtha and Ng 1977; Roy and Johnson 1973; Putler 1987; Kulshreshtha 1971; Chyc and Goddard 1994). However, no previous Canadian egg demand studies have explored the possible information interaction effects on egg consumption. Furthermore, there are no studies investigating egg demand using recent data for Canada.

**Parametric method**

Following Goddard (1988) and Edgerton (1997) a two-stage budgeting process is adopted assuming (i) weak separability of eggs from other foods and nonfood goods and (ii) the group price indices being used do not vary too greatly with the utility level or expenditure level. In the two stage budgeting process, budget allocation takes place in two independent steps. In the first stage, aggregate expenditure is allocated among n broad groups of goods (e.g., eggs, meat, breakfast cereals, etc). This process can be expressed using double-log functional form as follows (Goddard 1988):

$$\ln(M) = f\left(P^S, Y, P^{SC}, \ln M_{t-1}, f(A), AD^{SC}, S_k, t, h(\text{Media})\right) \qquad [1]$$

where $P^S$ is Stone's price index ($\ln P^S = \sum_{i=1}^{n} w_i \ln p_i$); $p_i$ = real prices of eggs (i=1, 2, 1= shell eggs, 2=breaker eggs); M is per capita real expenditure on eggs; $P^{sc}$ 's are prices of substitutes (=breakfast cereals) and complements (=ham and bacon); $AD^{SC}$'s are advertising expenditures for substitutes (breakfast cereals) and complements (=ham and bacon) products; $f(A_t)$ are functions of per capita advertising expenditure on eggs; $\ln M_{t-1}$ is lagged per capita expenditure; $S_k$ is seasonality (quarterly); t represents preference change over time; *h*(media) is the number of articles mentioning the relationship between eggs and cholesterol and eggs as a functional food..

In the second stage, group expenditure is allocated between individual good (e.g., shell eggs, breaker eggs, etc). Based on a consumer cost minimization problem, the Almost Ideal Demand System (AIDS)[4] model of Deaton and Muellbauer (1980) gives the share equations in an n-good system as:

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[4] Initially, the Quadratic AIDS (QUAIDS) was specified to allow for non-linear Engle's curve. However, the QUAIDS model performed statistically poorer.

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \ln\left(M/P\right) \quad [2]$$

where $w_i$ is the budget share associated with the i-th good, $\alpha_i$ is the constant coefficient in the i-th share equation, $\gamma_{ij}$ is the slope coefficient associated with the j-th good's price in the i-th budget share equation, $p_j$ is the real price on the j-th good. M is the per capita real expenditure given by

$$M = \sum_{i=1}^{n} p_i q_i \quad [3]$$

where $q_j$ is the quantity demanded for the i-th good. P is the price index defined by

$$\ln P = \alpha_0 + \sum_{i=1}^{n} \ln p_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln p_i \ln p_j \quad [4]$$

in the nonlinear AIDS model. Deaton and Muellbauer (1980) also suggested a linear approximation of the nonlinear AIDS model by specifying a linear price index given by

$$\ln P = \sum_{i=1}^{n} w_i \ln p_i \quad [5]$$

that gives rise to the linear approximate AIDS (LA-AIDS) model. In practice, the LA-AIDS model is more frequently estimated than the nonlinear AIDS model, in spite of its limitations.

Regularity properties of demand function implies the following restrictions on the parameters in the nonlinear AIDS model (adding-up): $\sum_{i=1}^{n} \alpha_i = 1$, $\sum_{i=1}^{n} \beta_i = 0$, $\sum_{i=1}^{n} \gamma_{ij} = 0$ ; homogeneity is satisfied if and only if, for all i, $\sum_{j=1}^{n} \gamma_{ij} = 0$ ; and symmetry is satisfied if $\gamma_{ij} = \gamma_{ji}$ .

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In the empirical estimation of the demand system, the AIDS model is augmented by incorporating shell egg advertising expenditure $\{f(SAD_t)= \theta^{tS}{}_i SAD_t+\theta^{tS}{}_i SAD_t.t\}$, breaker egg product advertising expenditure $\{f(BAD)= \theta^{B}{}_i BADt+\theta^{tB}{}_i BAD_t.t\}$, egg-cholesterol popular press media coverage $\{h(\text{Media})\}$, habit formation ($q_{it-1}$), seasonality ($S_k$), and trend (t) in the Canadian egg consumption data. Thus, the final budget share equations to be estimated for the time series data are expressed as follows:

$$
\begin{aligned}
w_{it} &= \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_{jt} + \beta_i \ln\left( M_t \big/ P_t \right) \\
&\quad + \sum_{k=1}^{3} \vartheta_{ik} S_{kt} + \tau_i t + \theta_i^S f(SAD_t) + \theta_i^B g(BAD_t) + \phi_i h(Media_t) \qquad [6] \\
&\quad + \sum_{j=1}^{n} \delta_{ij} q_{jt-1} + \chi_i^S SAD_t xMedia_t + \chi_i^B BAD_t xMedia_t
\end{aligned}
$$

where $\vartheta_{ik}, \tau_i$, $\theta_i$, $\phi_i$, $\chi_i^B$, $\chi_i^S$ and $\delta_{ij}$, respectively, represent parameters on the seasonal dummy variables[5], the time trend variable, the advertising variable, on the egg-cholesterol popular media coverage variable, shell egg advertising-media interaction, breaker egg advertising-media interaction and habit formation. Since the budget shares sum to 1, these parameters should satisfy

$$
\sum_{i=1}^{n} \vartheta_{ik} = 0, \quad \sum_{i=1}^{n} \tau_i = 0, \quad \sum_{i=1}^{n} \theta_i = 0, \quad \sum_{i=1}^{n} \phi_i = 0, \quad \sum_{i=1}^{n} \delta_{ij} = 0 \quad \sum_{i=1}^{n} \chi_i^s = 0 \quad \sum_{i=1}^{n} \chi_i^B = 0
$$

***Data***

The egg demand model estimated in this study includes shell eggs and breaker eggs on a per capita basis. Quarterly data from 1978 to 2001 are used. The data consists

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[5] The trigonometric approach (i.e., $\vartheta_i^c \cos\frac{2\pi t}{4} + \vartheta_i^s \sin\frac{2\pi t}{4}$) to capture seasonal effects and advertising variables were also implemented. But based on Likelihood Dominance Criterion (Pollak and Wales 1991) the dummy variable approach outperformed the trigonometric method.

of aggregate time series quarterly retail price, per capita consumption, real per capita generic advertising, and egg-cholesterol information for shell and breaker eggs. Egg disappearance, price and price index data, population, income are obtained from the Statistics Canada CANSIM database. Population, Consumer Price Index for all goods, and personal disposable income, are also obtained from CANSIM. Media indices are created through access to the FACTIVA database (Dow Jones/Reuters), advertising expenditure data on eggs and related products are sourced from A C Neilsen. Egg prices, generic advertising expenditure and personal disposable income are deflated by the consumer price index for all goods. The media information index is constructed as the difference between the number of positive and negative news articles (i.e., the number of *positive* minus *negative*) as a proxy for consumers' awareness of egg-cholesterol link (mostly negative news) and introduction into the market of new functional egg products (positive news). The justification for this procedure is based on the assumption that both messages types are assumed to have an influence on consumer decision making concerning egg consumption.

Table 1: Variable Definition

| Variable | Definition | Sources |
|---|---|---|
| $P_1$ | Log of real prices of shell eggs ($/dozen) | Statistics Canada, CANSIM |
| $P_2$ | Log of real prices of shell eggs ($/dozen) | |
| $P_{bf}$ | Log of breakfast cereals price | Statistics Canada, CANSIM |
| $P_{hb}$ | Log of ham and bacon price | Statistics Canada, CANSIM |
| M | Log of per capita real egg expenditure ($ per person) | === |
| Y | Log of per capita disposable income ($ per person) | Statistics Canada, CANSIM |
| SAD | Log of per capital shell egg generic advertising expenditure ($ per person) | |
| BAD | Log of per capital breaker egg products generic advertising expenditure ($ per person) | |
| CAD | Log of breakfast cereals advertising | |
| HAD | Log of Ham and Bacon advertising | |
| Media | Positive information relating eggs consumption and cholesterol, and new functional egg development (#). (Negative minus positive) | Factiva (Dow Jones/Reuters) |
| QI | Dummy variable capturing the first quarter of the year, 1 if QI=January, February and March, 0 otherwise. | === |

| | | |
|---|---|---|
| QII | Dummy variable capturing the first quarter of the year, 1 if QII=April, May, and June, 0 otherwise. | === |
| QIII | Dummy variable capturing the first quarter of the year, 1 if QIII= July, August and September, 0 otherwise. | === |
| QIV | Dummy variable capturing the first quarter of the year, 1 if QIV=October, November, and December, 0 otherwise. | === |
| T | Time trend to capture change in taste over time | === |
| $M_{t-1}$ | One period lagged log of per capita real egg expenditure | === |
| $Y_{t-1}$ | One period lagged log of per capita disposable income | |
| $w_1$ | Budget share of shell eggs | === |
| $w_2$ | Budget share of breaker eggs | === |
| $q_1$ | Per capita disappearances of shell eggs | |
| $q_2$ | Per capita disappearances of breaker eggs | |
| $q_{1t-1}$ | Lagged log per capita disappearances of shell eggs | === |
| $q_{2t-1}$ | Lagged log per capita disappearances of shell eggs | === |
| SADx Media | Interaction term between shell egg advertising and egg-cholesterol information | === |
| BADx Media | Interaction term between breaker egg products advertising and egg-cholesterol information | === |

## Results

### Nonparametric Results:

For the parametric analysis the Matrix Φ is constructed with 96×96 dimension, resulting in 9216 number of pairs, where the first raw can be defined as the expenditures for buying 96 different bundles (i.e., shell eggs and breaker eggs bundle) at 1978:1 prices; the second raw, the expenditure on buying the same bundles at the 1978:2 prices; the third raw, the expenditure on buying the same bundles at the 1978:3 prices, and so on. To test for GARP, mathematical procedures are written in MATHEMATICA (Varian). The null hypothesis for GARP test is that all observed choices are consistent with maximization of the same utility function of the representative consumer. First, the Afriat expenditure similarity parameter, e, for the GARP test is specified as 100% consistent with GARP, (or e is set to 1). Next, to take into account GARP violations that may occur due to measurement error, e is set to 0.99 (e.g., Famulari 1995; Jin and Koo 2003).

Table 2: Generalized Axiom of Revealed Preference Test

| Sample Range | Sample Size | Number of Pairs | Number of Violation | Violation rate |
|---|---|---|---|---|
| 1978:1-2001:4 (e=1.00) | 96 | 9216 | 31 | 0.34% |
| 1978:1-2001:4 (e=0.99) | 96 | 9216 | 4 | 0.04% |
| **Appearance of Positive News** | | | | |
| 1978:1-1989:4 (e=1.00) | 48 | 2304 | 11 | 0.48% |
| 1978:1-1989:4 (e=0.99) | 48 | 2304 | 0 | 0.00% |
| 1990:1-2001:4 (e=1.00) | 48 | 2304 | 16 | 0.69% |
| 1990:1-2001:4 (e=0.99) | 48 | 2304 | 0 | 0.00% |
| **Ω-3 Functional egg** | | | | |
| 1978:1-1992:2 (e=1.00 | 58 | 3364 | 13 | 0.39% |
| 1978:1-1992:2 (e=0.99) | 58 | 3364 | 0 | 0.00% |
| 1992:3-2001:4 (e=1.00) | 38 | 1444 | 10 | 0.69% |
| 1992:3-2001:4 (e=0.99) | 38 | 1444 | 0 | 0.00% |
| **Atkins Diet Popularization** | | | | |
| 1978:1-1996:4 (e=1.00 | 76 | 5776 | 30 | 0.52% |
| 1978:1-1996:4 (e=0.99) | 76 | 5776 | 2 | 0.03% |
| 1997:1-2001:4 (e=1.00) | 20 | 400 | 0 | 0.00% |
| 1997:1-2001:4 (e=0.99) | 20 | 400 | 0 | 0.00% |

Results for the sample period and sub-samples are given in Table 2. For the sample period studied, there were 31 (0.34%) violations of GARP when expenditure similarity parameter is set to 1.00 and 4 violations for e=0.99. Based on the GARP test, the hypothesis that the representative consumer maximizes constrained utility may be rejected. It should be noted that some of these violations may be caused by egg-cholesterol media news, the introduction into the market of functional eggs (such as omega-3), popularization of Atkins' diet (i.e., low carb diet), or measurement error or/and utility maximization assumptions. For example, when e = 0.98, there are no GARP violations observed.

To further check if the timing and pattern of the violations are consistent with the timing of the major structural change drivers (such as marketing of functional eggs, negative information, low-carb diet, etc), the GARP test is repeated within subsets of the whole sample (Figure 2). Based on Figure 2, for example, the sample is split into two sub-samples based on the switch in the net information effects. In 1990, the net media information switched from negative dominance to positive dominance. Omega-3 eggs have been available in the market since 1992 and hence we split the data into two sub-samples (pre-omega-3 and post omega-3 periods). The Atkins diet was also popularized in the media around 1997 providing another data split reference point (pre and post Atkin's diet popularization period). Following Famulari's method (i.e., e=0.99) and splitting the data based on the hypothesized structural break drivers all GARP violations have disappeared, with the exception of Atkin's diet popularization period categories (see Table 2).

Given the above results, fitting the parametric demand model may be appropriate if we take into account the factors that cause violations of GARP. This holds only if we assume that the above violations (under e=1) are driven by either measurement error or structural variables, not by inconsistency of data with constrained utility maximization. Famulari summarizes this issue as follows:

> "*If consumption choices and budget constraints are consistent with GARP the vast majority of the time, then proceeding to fit the data with a common, static utility function seems warranted. If consumption choices frequently violate GARP, we should question inferences drawn from a parametric model, even if the estimated parameters appear to be consistent with utility maximization*." (Famulari 1995: p374).

The following section presents results from parametric demand analysis.

**Parametric Results**

This section presents the results from the parametric demand model. Equation [1] and [6] are estimated simultaneously using a non-linear procedure in TSP 4.2. Results are given in Table [3] and [4]. The parameters of the equation for breaker egg budget share, the omitted equation, are not reported. To be consistent with the constrained utility maximization hypothesis, the homogeneity, symmetry, and the adding-up conditions are imposed prior to estimation. The monotonicity of the indirect utility function in the prices requires that the expenditure shares are strictly positive. The monotonicity condition is fulfilled at every data point. The quasi-convexity of the indirect utility function requires that the matrix of Allen-Uzawa elasticities of substitution be negative semi-definite. This condition is checked at the mean value of the variables in the model using eigenvalues of Allen-Uzawa elasticities of substitution and is satisfied.

Table 3: Parameter estimates of the expenditure function, 1978:1-2001:4

| Parameter | Estimate[6] | T-ratio | Parameter | Estimate | T-ratio |
|---|---|---|---|---|---|
| Constant | 3.054*** | 10.189 | CADt-3 | 0.016* | 1.857 |
| P | 0.733*** | 8.944 | HADt-3 | -9.1E-03** | -2.063 |
| SADt-2 | 0.016*** | 1.824 | SAD x Media | 9.7E-03 | 2.073 |
| Mt-1 | 0.276*** | 4.576 | BADt-2 | -4.0E-03*** | -2.795 |
| T | -1.6E-03*** | -2.858 | BAD x Media | 6.8E-05 | 0.831 |
| Media | 0.112*** | 2.081 | QI | -0.086*** | -13.275 |
| Y | -0.103* | -1.536 | QII | -0.038*** | -6.541 |
| Pbf | -8.4E-03 | -0.164 | QII | -0.035*** | -6.093 |
| Phb | 0.086*** | 2.603 | | $R^2 = 0.989$ | |

Table 4: Parameter estimates of the expenditure share equation for shell eggs, 1978:1-2001:4

| Parameter | Estimate | T-ratio | Parameter | Estimate | T-ratio |
|---|---|---|---|---|---|
| Constant | 1.361*** | 9.488 | Media | 0.021 | 0.887 |
| P1 | 0.077*** | 12.696 | $q_{1t-1}$ | 0.107*** | 3.051 |
| M-P | -0.212*** | -5.582 | $q_{2t-1}$ | -0.018** | -1.974 |
| SAD x T | 6.1E-05*** | 4.254 | T | -2.4E-06 | -1.054 |
| SAD x Media | 1.6E-03 | 0.796 | QI | -0.024*** | -5.438 |
| BAD | -3.1E-06 | -0.512 | QII | -0.012*** | -4.057 |
| BAD x Media | 2.1E-04 | 1.460 | QIII | -0.011*** | -4.046 |
| | | $R^2 = 0.832$ | | | |

The model fits the data very well as indicated by the high $R^2$ values and the magnitude of most t statistics (system's $R^2$ is 0.99). The price of shell eggs has a significant positive effect on shell egg expenditure share. As expected the shell egg generic advertising variable has a significant effect on both total egg expenditure and shell egg expenditure shares. The coefficient on the media information index is

[6] Note: ***, **, and * refer to 1%, 5% and 10% level of significance, respectively.

significantly positive in the expenditure equation. The parameter estimate on the interaction term between breaker egg products advertising and media information index (i.e., BAD x Media) is significantly positive, indicating that media coverage has increased the impact of breaker egg product advertising on egg expenditure. The coefficient on the ham and bacon price is significantly positive in the egg expenditure equation. The coefficients on seasonality dummies are highly significant and are negative. In the equation for shell egg budget share, lagged shell egg quantity is significantly positive suggesting that habit formation has increased current shell egg expenditure.

One of the purposes of this study is to explore consumers' response to egg-cholesterol and functional egg media coverage, and generic advertising expenditures. To determine the effects of these variables on the quantity demanded, elasticities are estimated. Conditional price elasticities of demand and expenditure elasticities are computed following Goddard (1988) and Edgerton (1997):

$$e_{ii} = \frac{\gamma_{ii}}{\hat{w}_i} - \beta_i - 1, \qquad e_{ij} = \frac{\gamma_{ij}}{\hat{w}_i} - \beta_i \frac{\hat{w}_j}{\hat{w}_i}, \qquad \eta_i = \frac{\beta_i}{\hat{w}_i} + 1$$

where the $\hat{w}$'s are the estimated budget shares, $e_{ii}$ and $e_{ij}$ are own and cross price elasticities, and $\eta_i$ is expenditure elasticity. Conditional advertising elasticities (Goddard 1988) are given as follows: $\pi_{ij} = \frac{\theta_{ij}}{w_i}$. The conditional total advertising elasticities, that integrate the interaction effect, are estimated as: $\pi_{ij} = \frac{\theta_{ij}}{w_i} + \frac{\chi_{ij}}{w_i} h(media)$.

**Price Elasticities**

Both conditional and unconditional elasticities (Goddard 1988; and Edgerton 1997) are estimated at the mean value and are presented in Tables [5] and [6]. The own and cross price elasticities are statistically significant for both conditional and unconditional Marshallian egg demand. Shell egg demand is more price elastic as compared to breaker egg.

Both shell and breaker egg elasticities with respect to breakfast cereals price are insignificant. Egg demand elasticities with respect to ham and bacon's price are significant and negative for shell eggs and positive for breaker eggs, suggesting that ham and bacon are gross complements to shell eggs and gross substitutes for breaker eggs.

Table 5: Short-run Conditional and Unconditional Price, Advertising, Egg-cholesterol, and Expenditure Elasticities of Egg Demand, 1978:1-2001:4 (at the mean value)

| | Conditional Elasticities | | | | Unconditional Elasticities | | | |
|---|---|---|---|---|---|---|---|---|
| | Shell Egg | | Breaker egg | | Shell Egg | | Breaker egg | |
| Variables | Estimates | T-ratio | Estimates | T-ratio | Estimates | T-ratio | Estimates | T-ratio |
| Marshallian Price | | | | | | | | |
| Sell Egg | -0.704*** | -19.488 | -3.193*** | -8.202 | -0.189*** | -3.205 | -2.975*** | -8.226 |
| Breaker Egg | -0.064*** | -7.476 | -0.310*** | -3.352 | 0.451*** | 7.393 | -0.092 | -1.151 |
| Expenditure | 0.768*** | 18.462 | 3.503*** | 7.813 | -0.079* | -1.527 | -0.362* | -1.514 |
| Breakfast Cereal Price | == | == | == | == | 0.002 | 0.164 | -0.021 | -0.164 |
| Ham and Bacon Price | == | == | == | == | -0.020** | -2.412 | 0.214** | 2.412 |
| Breakfast Cereal Ads | == | == | == | == | -0.004* | -1.785 | 0.002** | 1.984 |
| Ham and Bacon Ads | == | == | == | == | 0.040* | 1.785 | -0.023** | -1.984 |

**Advertising Elasticities**

The conditional own and cross shell egg advertising elasticities are significant, suggesting that advertising has both own and spillover effects. For the unconditional Marshallian egg demand, only the own shell egg generic advertising elasticity is significant and positive. Unconditional own and cross breaker egg product advertising elasticities are significant. Breaker egg product advertising has a negative effect on shell egg and positive effect on breaker egg expenditure share.

Unconditional shell and breaker egg elasticities with respect to breakfast cereals advertising are statistically significant, and negative for shell egg and positive for breaker egg. Estimates of ham and bacon advertising elasticities are also significant, and positive for shell egg and negative for breaker egg.

**Media Elasticities**

The unconditional media information index elasticity is significant and positive with respect to shell eggs suggesting that positive media has increased shell egg consumption. Figures [4] and [5] depict the shell egg conditional and unconditional elasticity of media information index over time.

**Advertising-Media Interaction Effects**

To explore the effect of positive egg-cholesterol media coverage, advertising elasticities are calculated with and without the egg-cholesterol interaction term in advertising elasticity formula. For example, when the interaction between advertising and egg-cholesterol media is accounted for, advertising elasticities of shell eggs has increased from as low as 5.70E-04 to 3.80E-03, 3.20E-03 point increase for the conditional demand function, and from 1.60E-02 to 1.90E-02, a 3.0E-03 point increase, for the unconditional demand relationship.

Table 5: Short-run Conditional and Unconditional Advertising and Egg-cholesterol Elasticities of Egg Demand, 1978:1-2001:4 (at the mean value)

| | **Conditional Elasticities** | | | | **Unconditional Elasticities** | | | |
|---|---|---|---|---|---|---|---|---|
| | Shell Egg | | Breaker egg | | Shell Egg | | Breaker egg | |
| Variables | Estimates | T-ratio | Estimates | T-ratio | Estimates | T-ratio | Estimates | T-ratio |
| **Without Interaction (DE)** | | | | | | | | |
| Shell Egg Ads | 5.7E-04 | 8.0E-01 | -6.1E-03 | -8.0E-01 | 1.6E-02** | 2.3E+00 | 2.2E-02 | 7.0E-01 |
| Breaker Egg Ads | -8.3E-04* | -1.5E+00 | 7.7E-05* | 1.5E+00 | -3.2E-03*** | -2.7E+00 | 1.6E-02** | 2.4E+00 |
| Media | 7.6E-03 | 8.9E-01 | -8.2E-02 | -8.9E-01 | 9.4E-02** | 2.1E+00 | 3.0E-02 | 3.4E-01 |
| **Interaction effect (IE)** | | | | | | | | |
| Shell Egg Ads x Media | 3.2E-03*** | 4.3E+00 | -3.5E-02 | -4.3E+00 | 3.0E-03** | 1.9E+00 | 5.0E-03 | 6.7E-01 |
| Breaker Egg Ads x Media | -1.8E-03 | -5.1E-01 | 1.8E-03 | 5.1E-01 | 9.4E-05* | 1.7E+00 | -7.5E-04 | -1.3E+00 |
| **Total Effect (DE+IE)** | | | | | | | | |
| Shell Egg Ads | 3.8E-03*** | 3.7E+00 | -4.1E-02*** | -3.7E+00 | 1.9E-02*** | 2.6E+00 | 2.7E-02 | 8.4E-01 |
| Breaker Egg Ads | -2.6E-03 | -7.3E-01 | 1.8E-03 | 5.3E-01 | -3.1E-03*** | -2.7E+00 | 1.5E-02** | 2.2E+00 |
| Media | -4.2E-04* | -1.5E+00 | 4.5E-03* | 1.5E+00 | -1.5E-04 | -2.5E-01 | 5.7E-03** | 2.0E+00 |

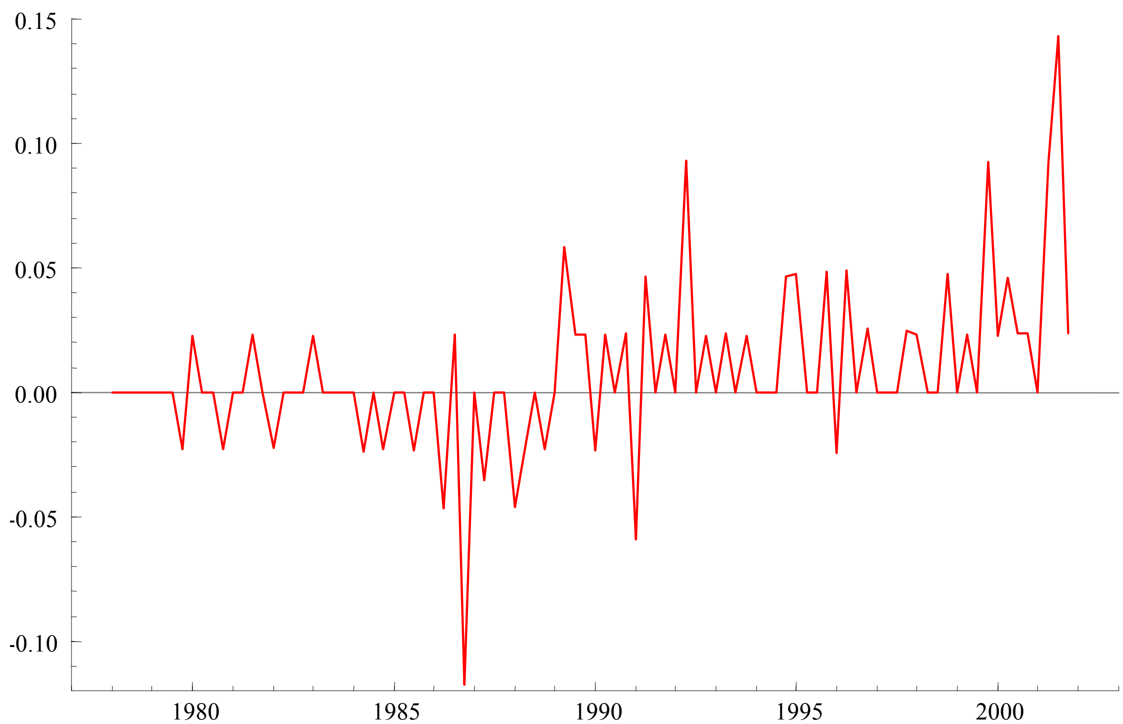


Figure 4 Conditional Media Information Index Elasticity of Shell Egg Demand (1978:1-2001:4)

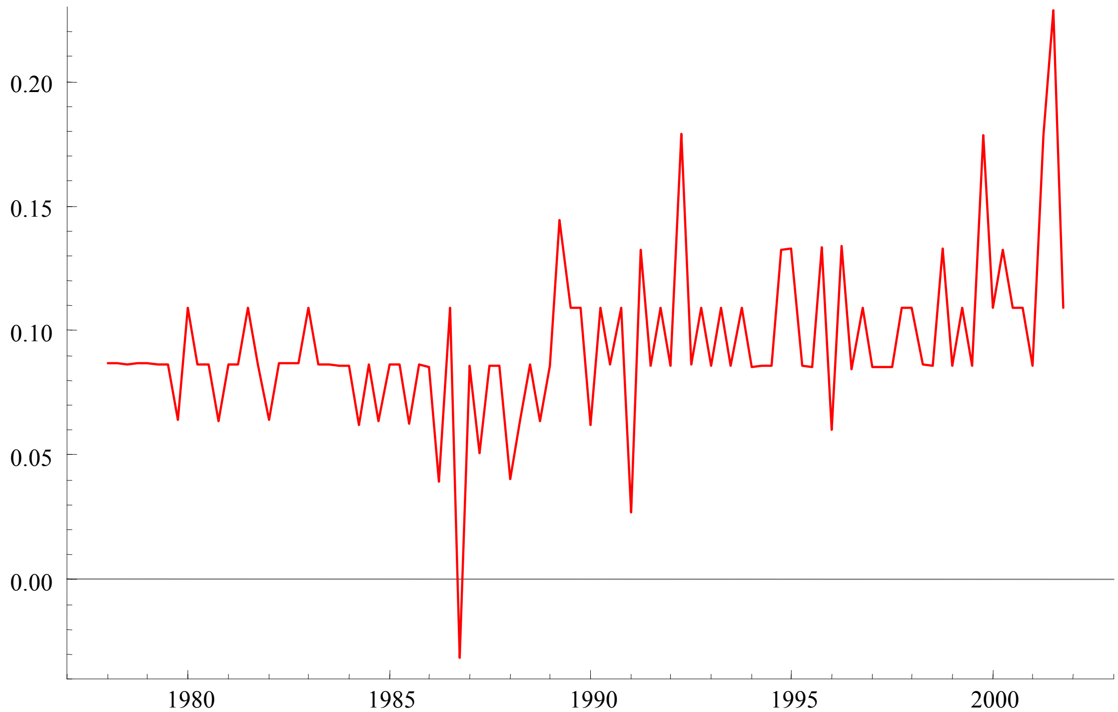


Figure 5 Unconditional Media Information Index Elasticity of Shell Egg (1978:1-2001:4)

## Concluding remarks

Nonparametric and parametric demand analyses are used to investigate the structural changes in egg consumption in Canada over the period 1978:1-2001:4. The nonparametric empirical results show that Canadian egg demand has undergone structural change, consistent with various media influences, such as egg-cholesterol news coverage, introduction of new products into the market, popularization of Atkin's diet and other variables. Apart from the unknown power of the nonparametric tests (Chalfant and Alston 1988), they may give an important indication of structural change in egg demand, results that can be combined with parametric demand analysis.

The results from the parametric method revealed that the impacts of advertising and media information index are significant and time varying. Furthermore, the media information index is found to have a significant effect on the size of the advertising elasticities. With a larger number of positive media articles, the bigger the impact of shell egg advertising. In the parametric analysis, the sign and size of elasticities are also affected by model specification (e.g., conditional vs. unconditional elasticities).

Further research may be necessary to explore the individual effects of negative and positive media information rather than using the net effect. It is also important to investigate the potential impact of media information and advertising on price responses.

The results of this study provide important information for policy makers and producers, processors in the egg industry. The results suggest a relationship between the direct shell egg disappearance and indirect breaker egg disappearance existing in Canada. Consumers are substituting egg products and prepared foods for purchases of shell eggs. In Canada, this trend may have implications for industry pricing under the supply managed regulatory system. Further research is warranted.

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