The changing egg demand in Canada: do advertising and health message contents matter?

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Introduction

Increasingly, 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 hypercholesterolemia resulted in a steady decline in per capita shell egg consumption. Cholesterolphobia has been acclaimed as a major cause of decline in per capita egg consumption (Brown and Schrader 1990a; Ballesteros et al. 2004; Ballesteros et al. 2004). Because egg yolk has a high cholesterol concentration, limited egg consumption is often suggested to help prevent ischemic heart disease (Nakamura et al., 2004).

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 a 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.

How consumers respond to the different media influences has important implications for the industry. Meanwhile, this research highlights whether there are interactive effects 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 the benefit from consuming eggs if there is intensive media coverage of the egg-cholesterol-heart diseases link. Advertising impacts may be greater or smaller (or insignificant) depending upon the media coverage of other egg related information. Industry responses such as advertising expenditure and their

message contents can be exacerbated or ameliorated by the impact of positive other media coverage. The questions are then: "How do consumers respond to different kinds of information on eggs consumptions? Is the impact of generic advertising on eggs consumption influenced by the content of egg advertising messages and popular media coverage? Increased understanding of the consumer responses to various types of information (often complex and confusing) can improve the efficacy of the advertising efforts by Canadian Eggs Marketing Agency (CEMA) and various provincial marketing boards.

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.). Meanwhile, there is a growing 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.

The objectives of the paper are (i) to test whether there is a structural change in the egg demand of Canadian consumers due to popularization of egg-cholesterol link and the development of functional egg products using a nonparametric approach; (ii) to econometrically scrutinize the impact of advertising of eggs and egg substitute products, popular media coverage concerning cholesterol-egg link and functional eggs development; and (iii) to further investigate the interactive 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.

1. 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 16.5 dozen per person in 2006 (Figure 1). Although several factors have contributed to the decline in per

capita disappearance of eggs, 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 the risks of heart disease (McIntosh 2000). In recent years, concern for animal welfare has also been growing (Appleby 2003). The egg industry has responded through research on nutritional attributes of eggs, the development of functional eggs (Omega-3 enhanced eggs, vitamin-enriched eggs), and adoption of alternative production system (e,g., free-run, free-range, organic, antibiotic free). With this new emphasis on the egg's positive attributes, per capita consumption has 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 studies claim that the egg-cholesterol-heart disease hypothesis is controversial and unproven (McIntosh 2000a). For example, recent finding suggest that eating two eggs a day helped maintain LDL/HDL cholesterol levels a pediatric population from northern Mexico (Ballesteros et al. 2004). Other studies revealed that increased consumption of eggs was associated with a decreased risk of breast cancer (Frazier et al. 2003). As Applegate (Applegate 2000: p495S) point out: "For years, eggs have been held up as a powerhouse of nutrition. This reputation has been due to eggs' exceptional nutrition profile as a nutrient-dense food containing high quality protein and a substantial amount of many essential vitamins and minerals. Unfortunately their position on the nutrition pedestal fell with the discovery that they are also a source of dietary cholesterol. The most recent scientific research not only returns eggs to their golden past, but elevates their position as a functional food and ultimately provides more reasons than ever to consume eggs."

Eggs are unlikely to alter blood lipid levels when consumed as part of a low-fat eating pattern, (e.g., Kritchevsky and Kritchevsky. 2000; MacNamara, 2000). Based on an review of epidemiologic data relating dietary cholesterol and eggs to coronary disease risk, Kritchevsky and Kritchevsky (2000) note that scientific research has not established a significant independent relationship between dietary cholesterol and LDL or total serum cholesterol levels, incidence of heart disease or heart disease deaths. "When dietary confounders were

considered, no association was seen between egg consumption at levels up to 1 + egg per day and the risk of coronary heart disease in non-diabetic men and women." (Kritchevsky and Kritchevsky 2000: 549S). "It is concluded that within the range of egg intake ... differences in egg consumption were unrelated to blood cholesterol level or to coronary heart disease incidence." (Dawber, et al. 1982: 617). Hu et al (1999: 1387) found that "1 egg per day is unlikely to have substantial overall impact on the risk of CHD or stroke among healthy men and women." MacNamara (2000) as well showed that dietary cholesterol is not related to coronary heart disease incidence or mortality across or within populations.

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 has levelled off. For example, "Japan has some of the lowest rates of coronary heart disease in the developed world. As Japan has become more affluent the rates of coronary disease have continued to fall. The Japanese diet frequently incorporates eggs, but in the context of a diet relatively low total fat and saturated fat. ..., over the period of declining heart disease rates in Japan, per capita egg consumption increased. Thus, the Japanese experience suggests that egg consumption is consistent with low coronary risk in the context of an otherwise heart healthy diet.' (Kritchevsky 2004: p. 599S). Research have also demonstrated that eggs are a source of highly bioavailable forms of the carotenoids lutein and zeaxanthin (antioxidant-like compounds) that help in the prevention of macular degeneration, a leading cause of blindness in the elderly, and have been associated with lower risk of cataract extraction (Moller et al. 2000). Meanwhile, 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. For example, according to the Food Marketing Institute survey (cited in Applegate 2000), 44 percent of consumers surveyed in the U.S.

reported being very or somewhat concerned about cholesterol levels in 1990. This number dropped steadily to 18 percent in 1999.

For Canada, 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 1). Over the same period, generic advertising expenditure (that by CEMA and various provincial egg marketing boards) has significantly increased (Figure 3). One other important factor is the change in the content of egg promotion messages (Table 1 and Figure 4). Canadian saw the very first TV commercial for Canadian eggs in early 1970. During these early days, the focus of the egg promotion was on taste, versatility, convenience and costs. Throughout the 80s, the major focus of advertising campaign was to handle cholesterolphobia by letting consumers know the existence of misconceptions about eggs and health connections. In the mid 90s, the focus of advertising campaign has shifted to the creation of positive nutritional attitudes using real egg producers and real egg consumers to tell how many eggs they have eaten in their lives. Beyond 2000, the TV campaigns promote the nutritional goodness of eggs.

2. Methods

This section outlines demand analysis methods used to investigate structural changes for egg demand. To test the implications of rational behaviour 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 1988b). Both parametric and nonparametric methods 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 behaviour. The nonparametric method employs economic logic based on the Axiom of Revealed Preference (Varian 1982a; 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, the 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 because it is a necessary and sufficient condition for data to be consistent with utility maximization (Varian 1982). .

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. The observed consumption data tell us that given prices p_t, the bundle q_t was chosen (Varian 1982b).

Suppose q_s is any other feasible bundle[2], where $p_t q_t \geq p_t q_s$. 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 q_s is also revealed to be preferred to bundle q_t (i.e, $q_s R q_t$), then the WARP is violated. Thus, WARP implies that $q_t R q_s \Rightarrow$ 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 $t \in [1, T]$[3]. 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 ϕ_{st} and ϕ_{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. Thus, WARP test is only a necessary condition[4].

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 (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 q_t is *strictly directly revealed preferred* to q_s. Put differently, GARP states that if q_t is revealed preferred to

[2] The bundle is defined as {shell eggs, breaker eggs}.
[3] For T time series observations, there are T*(T-1) pairewise comparisons of consumption bundles that either are consistent with or violate WARP.
[4] Violation of WARP or GARP can occur because of non-optimizing behaviour 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 q_s if and only if $(e.p_t q_t) > p_t q_s$, where e (expenditure similarity) is a value between zero and one.

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.

Parametric approach provides the significance of the effects of the taste-shifters 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 1990b; Schmit and Kaiser 1998; Loyns and Lu 1973; Kulshreshtha and Ng 1977; Roy and Johnson 1973; Putler 1987; Kulshreshtha 1971; Chyc and Goddard 1994). Chang and Just (2004) explored the impact of health information on egg consumption in the U.S. using various specification for health information index. In the U.S., Brown and Schrader (1990b), estimated the effect of cholesterol information on egg consumption by constructing a cholesterol information index. They found that information on the link between cholesterol and heart diseases has reduced per capita shell-egg consumption. Smed and Jensen (2005) analyzed the Danish demand for pasteurized and shell eggs and found that negative information about shell eggs induced a permanent increase in demand for pasteurized eggs.

Parametric Method

A two-stage budgeting process is adopted assuming (i) weak separability of egg from other foods and non-food goods and (ii) the group price indices being used do not vary too

greatly with the utility level or expenditure level (Edgerton, 1997). 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., egg, meat, breakfast cereals, etc).

In the second stage, group expenditure is allocated between individual good (e.g., shell egg and breaker egg). Based on a consumer cost minimization problem, the Almost Ideal Demand System (AIDS)[5] model of Deaton and Muellbauer (1980) gives the share equations in an n-good system as:

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

where w_i is the budget share associated with the i-th good, α_i is the constant coefficient in the i-th share equation, γ_{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

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

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

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

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

$$\ln P = \sum_{i=1}^{n} \overline{w}_i \ln p_i \qquad [5]$$

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 limitation. Regularity properties of demand function implies the following restrictions on the parameters

[5] Initially, the Quadratic AIDS (QUAIDS) was specified to allow for non-linear Engle's curve and interactions between prices. However, the QUAIDS model performed statistically poorer. The calculated chi-square value for a Likelihood Ratio test is 0.276, with 1 degree of freedom.

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 $\gamma_{ij} = \gamma_{ji}$.

In the empirical estimation of the demand system, the AIDS model is augmented by incorporating shell egg advertising expenditure, breakfast cereals advertising expenditure, egg-cholesterol link and egg-functional food popular press media coverage (i.e., media), habit formation (i.e., w_{it-1}), and seasonality. Thus, the final budget share equations to be estimated for the time series data are expressed as follows:

$$w_{it} = \alpha_i + \sum_{j=1}^{2}\gamma_{ij}\ln p_{jt} + \beta_i \ln(M_t / P_t) + \sum_{j=1}^{2}\delta_{ij} w_{jt-1} + \sum_{k=1}^{3}\theta_{ik} S_{kt} + \tau_i t + \theta_i^{AD} GAD_t$$
$$+ \theta_i^{CH} MEDIA_t + \theta_i^{B} BAD_t + \theta_i^{GC} GAD_t \bullet MEDIA + \theta_i^{CO} GAD_t \bullet CON_t + \theta_i^{CN} GAD_t \bullet CNV_t$$
$$+ \theta_i^{GP} GAD_t \bullet POS + \theta_i^{GB} GAD_t \bullet BAD_t + \theta_i^{BC} BAD_t \bullet MEDIA_t + \varepsilon_t$$

[6]

where GAD_t is the expenditure on generic egg advertising, BAD_t is the expenditure on generic breakfast cereals advertising, $MEDIA_t$ is media counts of information linking egg-cholesterol-heart diseases, CON_t is a dummy variable for advertising message content focussing on the importance of versatility, taste, affordability and convenience attributes of eggs (during the period 1975 – 1984), CNV_t is a dummy variable for advertising message content focussing on the importance of convenience attributes of eggs (during the period 1984 – 1995), POS_t is a dummy variable for advertising message content focussing on the importance of nutritional values of eggs, egg preparation, dismissal of the link to cholesterol (during the period 1995 – present), S_{kt}'s are quarterly dummy variables, t is time trend, θ_i's are parameters to be estimated. Since the budget shares sum to 1, these parameters should satisfy:

$$\sum_{i=1}^{n}\theta_i^k = 0,\ \sum_{i=1}^{n}\tau_i = 0 \quad \text{for } k = 1, 2.$$

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 of eggs demanded, elasticities are estimated. Conditional price elasticities of demand and expenditure elasticities are computed as:

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

where $\hat{w}$'s are the estimated budget shares, e_{ii} and e_{ij} are own- and cross- price elasticities, and η_i is expenditure elasticity. Advertising and media elasticities are given as follows: $\pi_{ij} = \frac{\theta_{ij}}{w_i}$.

3. 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 2006 are used. The data consists of aggregate time series quarterly retail price, per capita consumption, real per capita generic advertising, and egg-cholesterol-heart diseases information for shell and breaker eggs. Egg disappearance, price and price index data, population, personal disposable income, Consumer Price Index, are obtained from the Statistics Canada CANSIM database. Farm and import level prices of breaker eggs are obtained from Canadian Eggs Marketing Agency (CEMA) and Statistics Canada, respectively. The implicit import prices (i.e., unit value) of breaker eggs are calculated as import value divided by import quantity. Figure 5 shows the trends in shell and breaker eggs prices. The import level prices of breaker eggs are used as a proxy for retail prices of breaker eggs.

Advertising expenditure data on eggs and related products are obtained from A C Neilsen and various marketing boards. Egg prices, generic advertising expenditure and personal disposable income are deflated by the consumer price index for all goods. Table 2 summarizes variable definition and data sources.

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. Media indices are created through access to the FACTIVA database (Dow Jones/Reuters). Our media information index, Media, was created by scanning all media articles related to cholesterol, heart disease and eggs available at FACTIVA, a service of the a Dow Jones & Reuters Company that provides essential business news and information. We used key words "egg cholesterol heart disease". A total of 874 news articles were referenced in this subset over the period 1976:1-2006:4. The 874 abstracts and contents were carefully read and grouped into positive and negative information related news. The article counts are categorized as positive and negative by the type of information provided in the news articles. Positive news articles show a favorable link of functional eggs development on health. The negative articles comprise all articles which show unfavorable impacts of egg cholesterol on heart disease. Based on article counts, a media information index was developed. The media index is the sum of articles showing favorable impacts of eggs minus the sum of articles showing unfavorable impacts of egg cholesterol" $\text{Media} = \sum(\text{Media}^{+} - \text{Media}^{-})$, where media is media information index, Media^{+} is cumulative total of positive news articles for a given quarter, and *Media*$^{-}$ is cumulative total of negative news articles for a given quarter.

4. Results and Discussion

Results Nonparametric Demand Analysis

The GARP test is conducted to explore whether the aggregate egg data is consistent with the utility maximization behaviour. For the parametric analysis the Matrix Φ is constructed with 106×106 dimension, resulting in 13456 number of pairs, where the first raw can be defined as the expenditures for buying 106 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 (Varian) in Wolfram MATHEMATICA 7.0. 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).

The GARP test results for the sample period and sub-samples are given in Table 3. For the sample period studied, there were 41 (0.305%) violations of GARP when expenditure similarity parameter is set to 1.00 and 2 violations when expenditure similarity parameter is set to 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 the 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). For example, the sample is split into two sub-sample based on the switch in the net information indices (see Figure 2). In 1990, the net media information indices switched from negative to positive. Omega-3 eggs were available on the market since 1992 and hence we split the data into two sub-samples (pre-omega-3 and post omega-3 periods). The Atkins diets were also popularized in the media around 1997 providing another data split reference point (pre and post Atkin's diets 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 gone down, with the exception of the two violations post the hypothesised structural break periods (see Table 3). The two violations consistently the 2003:4 and the 2005:2 quarters.

In light of the fairly small percentage of violations for the whole sample period (41 out of 13456 chances), fitting the parametric demand model may be appropriate after controlling for some of the factors that potentially cause GARP violations. 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. "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.

Results: Parametric Demand Analysis

This section presents the results from the parametric demand analysis. Equation [1] is estimated using an ordinary least square procedure in TSP 4.2. Parameters estimates along with specification tests are reported in Table 4. 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.

The model fits the data well as indicated by the high R^2 values. Some of the results of specification test reported in Table 4 indicate misspecification: low p-values for heteroscedasticity (LM het and Breusch-Pagan het tests) and parameter instability (CUMSUMSQ). To correct for heteroscedasticity, a heteroscedastic-consistent matrix is used (Robust-White). Further, the dynamic specification is statistically significantly different from

the static model; the dynamic specification resulted in an approximately 15% improvement in error variability over the static model (See Edgerton, 1997). This result suggests that habit formation is one of the determinants of demand for eggs.

The price of shell eggs has a significant positive effect on the expenditure share of shell eggs expenditure. Generic advertising expenditure has a statistically significant effect on the expenditure shares of shell eggs. The coefficient on the interaction between media information index and shell eggs advertising expenditures is statistically insignificant but positive.

The effects of the interaction between generic shell eggs advertising expenditure and advertizing message content are statistically insignificant but positive. Breakfast cereals advertising expenditures have a significant positive effect on shell eggs expenditure shares. The coefficients on seasonality dummies are highly significant and are negative, suggesting that expenditures on shell eggs rise during the fourth quarter. As well, the coefficient of the trend variable is negative and statistically significant suggesting that a decline in expenditure share of shell eggs and a rise in expenditure share of breaker eggs over time.

Price elasticities of demand are estimated at the mean value and are presented in Table 5. The own and cross price elasticities are statistically significant. The Marshallian cross price elasticities are negative suggesting that shell eggs and breaker eggs are gross complementary. But Hicksian cross price elasticities suggest that shell eggs and breaker eggs are net substitute (i.e., $e_{SB} = 0.016$, $e_{BS} = 0.065$). The own and cross shell eggs generic advertising expenditures elasticities are statistically significant, suggesting that shell eggs advertising expenditures has both own and 'substitution' effects. Furthermore, the own shell eggs advertising elasticity is positive suggesting that advertising expenditure had a positive effect on the demand for shell eggs. Media information index elasticity is significant and negative with respect to shell eggs and positive with respect to breaker eggs, suggesting that positive media coverage has reduced the demand for shell eggs but it has increased the demand for breaker eggs.

5. Concluding remarks

Nonparametric and parametric demand analyses are used to investigate the structural changes in eggs consumption in Canada over the period 1978:1-2006:4. The nonparametric

empirical results show that Canadian eggs demand has undergone structural change, consistent with various media 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), it may give an important indication of structural change in eggs demand, results that can be combined with parametric demand analysis.

The demand for both shell and breaker eggs are directly influenced by popular media coverage. The results from the parametric method revealed that the effectiveness of shell eggs advertising expenditures, however, was not significantly influenced by media information index and the content of advertising messages. 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, producers, and processors in the egg industry. The results suggest the existence of a relationship between the direct shell eggs disappearance and the indirect breaker eggs disappearance 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.

In conclusion, both the parametric and nonparametric results suggest the presence of significant structural change in the demand for shell and breaker eggs in Canada. Our nonparametric and parametric test results support the hypothesis that s a structural change in the egg demand of Canadian consumers has occurred due to the popularization of egg-cholesterol link and the development of functional egg products using a nonparametric approach. But we did not find significant interactive effects among the different media influences in relation to informational variables such as egg nutrition and health information, and advertising.

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Figure 1: Per Capita Total (Shell plus Breaker) Egg Disappearance in Canada 1961-2006

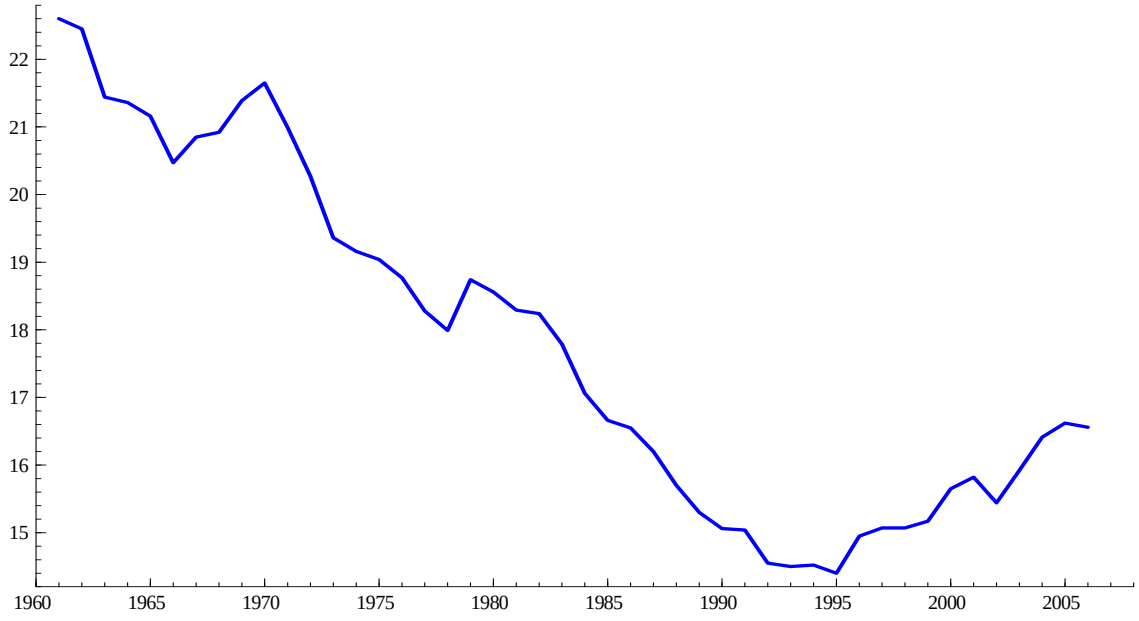

Figure 2: Net Egg-Cholesterol Information Index, 1976 – 2006.

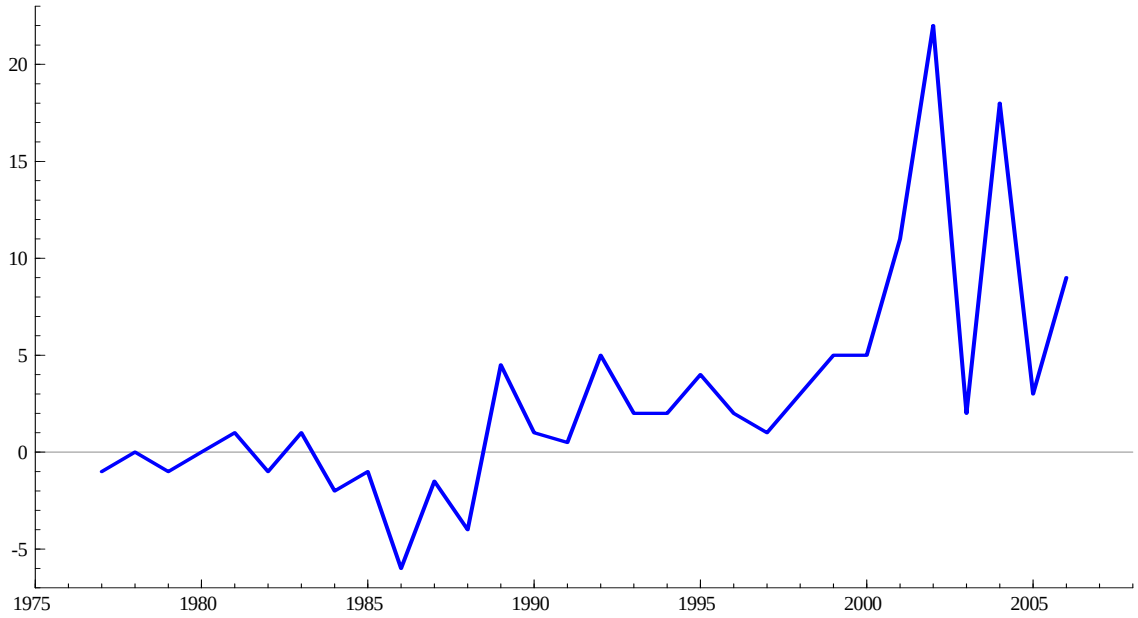

Figure 3: Generic Egg Shell Advertising Real Expenditure (CAN $), 1976-2006

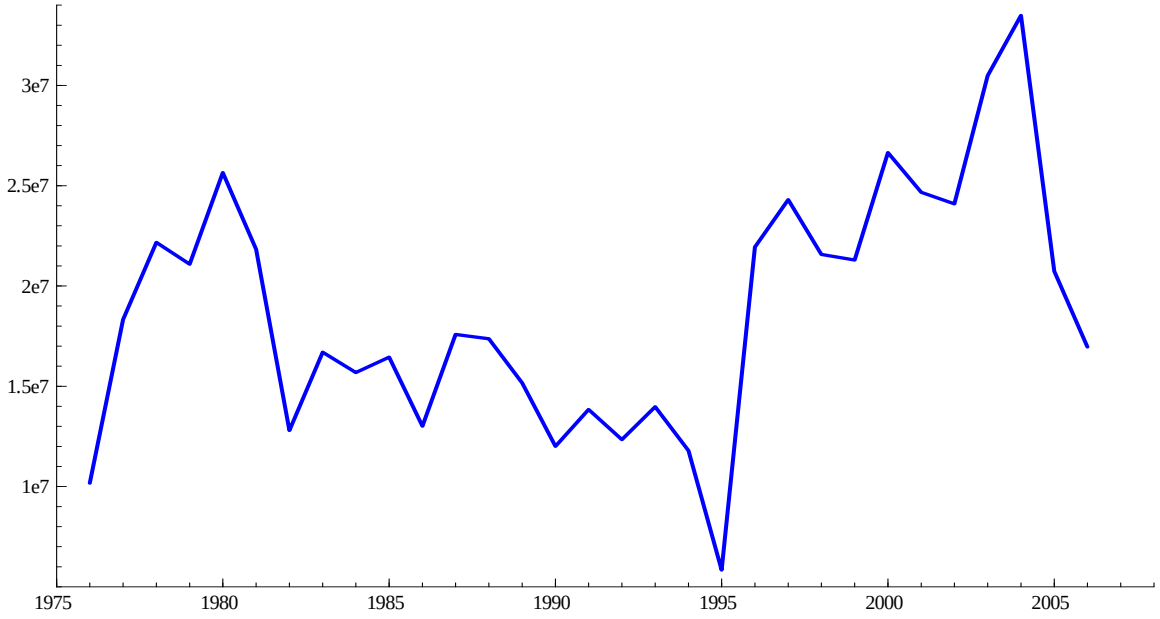

Figure 4: The Changing Contents of Egg Promotion Messages (1975-2000)

Period I	Period II	Period III
Marginal Cholesterol concern Versatility, Taste Economical Convenience	Handling Cholesterolphobia Convenience Egginstead	Create Positive Nutritional attitudes How to make egg dishes “Cholesterol has no effect”
1975 — 1984	1984 — 1995	1995 — 2000

Figure 5: Trends in Shell and Import Breakers Eggs Real Prices (1986 Base)

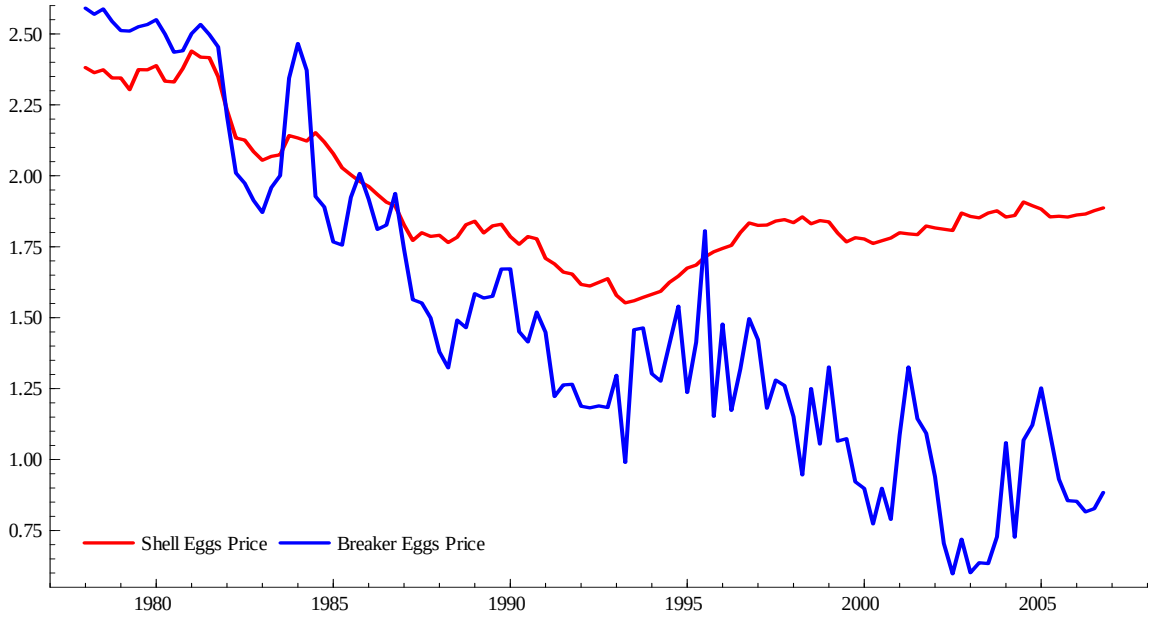

Table 1: Egg Advertising TV Campaign Message Content

Four From The Early Days (1970s)
☑ #1 = Taste, versatility and fun ☑ #2 = Economical ☑ #3 = In this fast paced world, it doesn't take long to prepare a great egg dish. ☑ #4 = Have eggs for breakfast
Take eggs out of the refrigerator more often by presenting them to consumers in innovative ways (1980s):
☑ Liberate Your Eggs for lunch ☑ Have Breakfast for Dinner
Handling Cholesterolphobia (1980s)
☑ First, let consumers know we were not happy about the misconceptions about eggs and health. ☑ Second, celebrate the goodness of eggs.
The Mid 90s
☑ Use real egg producers to create good feeling about eggs which led to positive nutritional attitudes. ☑ Use real egg consumers to tell how many eggs they have eaten in their lives. ☑ Show consumers how to make egg dishes.
2000 to Present
☑ TV campaigns to remind consumers eggs are good anytime, especially at dinner. ☑ Promote the nutritional goodness of eggs.

Source: Westendorp (2004), Marketing Manager, Ontario Egg Producers at the NEC-63 Conference, October 1, 2004.

Table 2: Variable Definition

Variable	Definition	Sources
LNP_{1t}	Log of real prices of shell eggs ($/dozen)	CANSIM
LNP_{2t}	Log of real prices of breaker eggs ($/dozen)	
M_t	Log of per capita real egg expenditure ($ per person)	= = =
Y	Log of per capita disposable income ($ per person)	CANSIM
S_{1t}	Dummy variable capturing the first quarter of the year, 1 if S_{1t} =January, February and March, 0 otherwise.	= = =
S_{2t}	Dummy variable capturing the first quarter of the year, 1 if S_{2t} =April, May, and June, 0 otherwise.	= = =
S_{3t}	Dummy variable capturing the first quarter of the year, 1 if S_{3t} = July, August and September, 0 otherwise.	= = =
S_{4t}	Dummy variable capturing the first quarter of the year, 1 if S_{4t} =October, November, and December, 0 otherwise.	= = =
T	Time trend to capture change in taste over time	= = =
w_{1t}	Budget share of shell eggs	= = =
w_{2t}	Budget share of breaker eggs	= = =
w_{1t-1}	One period lagged budget share of shell eggs	= = =
w_{2t-1}	One period lagged budget share of breaker eggs	= = =
BAD	Log of breakfast cereals advertising	
Media	Media eggs –cholesterol heart diseases link information, and new functional eggs development (#).	Factiva (Dow Jones/Reuters)
GAD	Log of per capital shell eggs generic advertising expenditure ($ per person)	
BAD • Media	Interaction term between shell eggs generic	= = =

	advertising and egg-cholesterol information	
BAD • Media	Interaction term between breakfast cereals advertising and egg-cholesterol information	= = =
GAD_t • CON[6]	Period I (1970 –1985) shell eggs advertising	= = =
GAD_t • CNV_t	Period II (1986-1995) shell egg advertising	= = =
GAD_t• POS_t	Interaction term between Period III (2000-present) shell egg advertising	= = =
P_t	A linear price index (Stone's price index)	= = =

Table 3: 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)	106	13456	41	0.305%
1978:1-2001:4 (e=0.99)	106	13456	2	0.015%
Appearance of Positive News				
1978:1-1989:4 (e=1.00)	48	2304	7	0.304%
1978:1-1989:4 (e=0.99)	48	2304	0	0.00%
1990:1-2001:4 (e=1.00)	68	4624	24	0.519%
1990:1-2001:4 (e=0.99)	68	4624	2	0.043%
Ω-3 Functional egg				
1978:1-1992:2 (e=1.00	58	3364	19	0.565%
1978:1-1992:2 (e=0.99)	58	3364	0	0.00%
1992:3-2006:4 (e=1.00)	58	3364	21	0.624%
1992:3-2006:4 (e=0.99)	58	3364	2	0.059%
Atkins Diet Popularization				
1978:1-1996:4 (e=1.00	76	5776	21	0.364%

[6] Based on shell eggs advertising message content four advertising expenditures are defined: advertising expenditures for the period 1975-84, 1985-1994 , and 1995-1999. and 2000 and beyond. Advertising expenditures for period IV is dropped from the analysis to avoid collinearity problem.

1978:1-1996:4 (e=0.99)	76	5776	0	0.0%
1997:1-2001:4 (e=1.00)	40	1600	15	0.937%
1997:1-2001:4 (e=0.99)	40	1600	2	0.125%

Table 4: Parameter Estimates of the Expenditure Share Equation for Shell Egg, 1978:1-2006:4

	Without message content /without media		without media		Unrestricted	
Variables	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat
Constant	4.7430	2.817	5.7923	3.155	5.9410	3.105
LnP_{1t}	0.1443	11.443	0.1444	11.494	0.1439	11.574
$\ln(M_t/P_t)$	-0.1409	-2.810	-0.1628	-2.861	-0.1703	-3.021
T	-0.0017	-12.299	-0.0016	-7.676	-0.0016	-7.655
S_{1t}	-0.0204	-3.594	-0.0209	-3.464	-0.0214	-3.612
S_{2t}	-0.0177	-3.581	-0.0180	-3.599	-0.0181	-3.686
S_{3t}	-0.0185	-3.877	-0.0185	-3.865	-0.0196	-4.131
$W_{(it-1)}$	0.3283	5.233	0.2830	4.203	0.2833	4.108
$Media_t$					-0.0022	-2.415
$Media_{(t-1)}$					0.0251	0.686
GAD_t	0.3208	2.163	0.4009	2.528	0.4114	2.458
$GAD_{(t-1)}$	-0.0008	-0.077	-0.0026	-0.244	-0.0024	-0.213
BAD_t	0.4244	2.203	0.5300	2.562	0.5466	2.501
$BAD_{(t-1)}$	0.0037	0.604	0.0077	1.200	0.0071	1.119
$GAD_t \bullet CON_t$			0.0011	1.378	0.0012	1.518
$GAD_t \bullet CNV_t$			0.0015	1.190	0.0015	1.184
$GAD_t \bullet POS_t$			0.0005	0.289	0.0003	0.170
$GAD_{(t-1)} \bullet Media_{(t-1)}$					0.0022	0.668
$GAD_t \bullet BAD_t$	0.0387	2.2108	0.0481	2.5596	0.0495	2.493
Model Diagnostics and Fitness						

LLF [LR test, df]	304.519	[12.2, 6]*	307.02	[7.2, 2]**	310.62	
Adj. R2		0.810		0.812		0.818
LM het					9.65***	
Durbin's h					0.312	
ARCH					2.25	
CuSumSq					0.524***	
Chow test					0.58	
Breusch-Pagan het					10.74***	
Jarque-Bera					0.26	
Ramsey's RESET2					2.497	

Table 5: Price, Advertising, Egg-cholesterol Media, and Expenditure Elasticities of Egg Demand, 1978:1-2006:4 (at the mean value)

	In Presence of Media Information and Advertising Message Content					
	Shell Egg Price	Breaker price	Egg Expenditure	Egg Adv.	Breakfast Adv.	Media
Shell	-0.6510	-0.1376	0.7885	0.5121	0.6787	-0.0009
	(-10.8376)	(-5.5607)	(10.9328)	(2.7710)	(2.8027)	(-2.5029)
Breaker	-1.4444	-0.4307	1.8752	-2.1193	-2.8090	0.0037
	(-5.8102)	(-4.2071)	(6.2816)	(-2.7710)	(-2.8027)	(2.5029)
	In the Absence of Media Information					
Shell	-0.6580	-0.1399	0.7979	0.4990	0.6581	
	(-10.6113)	(-5.6891)	(10.8905)	(2.8264)	(2.8414)	
Breaker	-1.4155	-0.4209	1.8365	-2.0651	-2.7236	
	(-5.5157)	(-4.1355)	(6.0564)	(-2.8264)	(-2.8414)	

Note: Figures in parentheses are t-ratios.