A Bilateral Comparison of Fruit and Vegetable Consumption: U.S. and Canada

Timothy J. Richards
Paul M. Patterson[1]

May 15, 2003

Presented at the
American Agricultural Economics Association Annual Meeting
Montreal, Quebec
July 27-30, 2003

Abstract: A structural latent variable model tests the role quality and information play in explaining observed differences in Canadian and U.S. produce consumption (5.0 vs. 3.5 servings/day). Dietary health information is significant in expanding demands. Quality promotes fruit consumption in Canada, consistent with the Alchian-Allen prediction. JEL: D120, I120.

---

[1] Authors are Power Professor and Associate Professor, respectively, in the Morrison School of Agribusiness, Arizona State University, 7001 E. Williamsfield Rd. Bldg. 20, Mesa, AZ. 85212. Contact author: Richards. Ph. 480-727-1488. FAX 480-727-1510. email: trichards@asu.edu. We gratefully acknowledge the financial support of the National Research Initiative - USDA program. This paper is funded under USDA-NRI Grant No. 00-35400-9121. All opinions expressed are of the authors and not the USDA.

Introduction

Through its “5 a Day for Better Health” program, the National Cancer Institute (NCI) and the Produce for Better Health Foundation (PBH) have spent an average of $1 million per year over the last decade to promote the consumption of fruits and vegetables. The health benefits of increased consumption of these products are clearly documented in the epidemiological literature, both in terms of reduced incidence of various forms of cancer (Block, Patterson, and Subar) as well other ailments such as stroke, heart disease, and obesity. In fact, USDA estimates the annual cost to the U.S. economy of poor diets in general of $5.1 to $10.6 billion dollars in health care costs, absenteeism, and early death (Frazão). Despite efforts to promote healthy eating, however, the number of fruit and vegetable servings per capita per day in the United States lags that in other countries of similar level of economic development (Waterfield, 1997; Johnson; Offner). Of particular concern is the stark difference in consumption between the United States and its largest, and most culturally similar neighbor – Canada. Whereas average consumption of fresh fruits and vegetables in the United States is approximately 3.5 servings per capita per day, Canadians consume an average of over 5 servings per day. Curiously, this difference persists in spite of the fact that Canada’s climate is not conducive to growing fruits and vegetables year-round as in the United States, requiring the importation of a large proportion of their fresh produce.

Explanations for the difference in consumption range from differences in ethnic composition of society to differences in income, relative prices, knowledge regarding the link between diet and health, the propensity to purchase and consume food away from the home, or relative quality of available produce (Waterfield, 1997; Johnson; Offner). Moreover, although difficult to measure, perceived quality is critically important to the demand for fresh produce. Indeed, because most of Canada's fresh produce supply is imported, the Alchian-Allen effect predicts that it will be of relatively higher quality than that consumed in the U.S., simply because transport costs exclude lower unit-value produce from the Canadian import market.

Despite the importance attached to fresh fruit and vegetable consumption by public health authorities, neither the Alchian-Allen effect nor any of the other potential explanations for lagging U.S. consumption levels has been rigorously documented or verified. Therefore, the objectives of this paper are to: (1) determine whether the accepted difference in U.S. and Canadian consumption of fresh fruits and vegetables is real or an artifact of different measurement systems, and (2) explain the gap as a result of prices, incomes, tastes and preferences, publicly provided nutritional and health information, or average produce quality. To fulfill these objectives, we estimate the impact of quality and information on fresh produce demand in each country. Moreover, we conduct two different comparisons – one using cross-sectional / time-series, or panel data sets and the other more aggregate, time-series data. Because neither quality nor information are directly observable, the demand models are estimated using a structural latent variable framework.

Empirical Model of Fresh Produce Demand

Whereas the quality of packaged or semi-processed foods usually varies little between purchases and can often be taken as given, the same cannot be said of fresh produce. Consequently, quality is considered as a latent variable, or one that cannot be directly observed so must be imputed from observed behavior and variation among truly observable demand-determinants. Consistent with industry observations that the best quality produce goes to export markets, we hypothesize that this variation in quality is largely responsible for observed differences in produce demand between Canada and the United States. This is the Alchian-Allen effect. Because transport charges constitute a fixed cost, exporters have an incentive to sell abroad products of the highest unit-value, and thereby the highest quality, in order to maximize total profits. If the Alchian-Allen effect provides a viable explanation for differences in fresh produce consumption levels between U.S. and Canada, we should observe a strong positive response of produce consumption to inherent produce quality. Unfortunately, however, this is not a trivial exercise as quality, like information, is unobservable, *per se*.

Consequently, to determine the impact of these unobservable factors on demand, our research proceeds in two stages. First, we construct a latent variable model of the information available to fresh produce consumers and the quality inherent in fresh fruits and vegetables in the U.S. and Canada. In the second stage, we estimate the impact of quality and information on demand by specifying demand systems for fresh produce in each country that incorporate fitted values for the latent variables that we recover from the latent variable model.

Joreskog and Goldberger (1971) develop a structural latent variable approach to identifying and estimating the impact of unobservable variables on observable quantities. Of this general class of model, this study uses a multiple indicator, multiple cause (MIMIC) variant. Gao and Shonkwiler use a similar approach to estimate the impact of changes in tastes and preferences on the demand for various types of meat in the US, while Patterson and Richards apply a MIMIC technique to estimate the effect of different advertisement characteristics on the demand for Washington apples. Variyam, *et al.* use a similar, yet somewhat simplified, factor analysis approach in estimating the latent effect of nutritional information on an index of dietary health.

Latent variables are typically modeled with proxies. Standard proxy variable models, however, are generally unacceptable for several reasons. First, proxy variables are erroneous measures of the true latent variables upon which demand is thought to depend, introducing potentially significant measurement error and, hence, inconsistency. Second, latent variables are likely to be endogenous. Thus, ordinary least squares, or any other limited-information approach, introduces potentially significant simultaneous equations bias. Third, introducing a single proxy variable may provide misleading results simply because there are many other possible proxies for any latent variable, each leading to a different estimate of the true effect. Consequently, measuring product quality and information, as well as their effect on consumption, requires an approach that not only explicitly recognizes the inherent latency of each, but also the many possible ways of measuring them.

A MIMIC model relies on covariance relationships between observable endogenous "indicators" of latent variables and exogenous observable "causes" to identify latent variable values that are otherwise unobservable. Formally, MIMIC models consist of two sets of equations: (1) measurement (or indicator) equations that describe the relationships between indicator variables and latent constructs, and (2) causal or structural equations that show how these latent variables are determined by observable, exogenous economic variables. While measurement equations are used to scale and identify the latent constructs, causal equations provide the parametric estimates that are of key interest to researchers. Formally, structural equations specify relationships between the set of latent variables ($\boldsymbol{\eta}$), their causes ($\boldsymbol{z}$), and a random error term ($\boldsymbol{\zeta}$):

$$\boldsymbol{\eta} = \boldsymbol{\Phi\eta} + \boldsymbol{\Gamma z} + \boldsymbol{\zeta}, \qquad \textbf{(1)}$$

where M and ' are parameter vectors showing the marginal effects of the latent variables on each other and the cause variables on the latent variables, respectively. Measurement equations, on the other hand, show how each indicator variable (***y***) is related to the latent variables, a vector of exogenous factors (***x***), and a vector of random measurement-errors (Joreskog and Goldberger; Bollen; and Anderson):

$$\boldsymbol{y} = \Lambda_y \eta + \boldsymbol{\beta} \boldsymbol{x} + \epsilon . \tag{2}$$

In this set of equations, the components of 7_y are also known as factor loading coefficients. Further, the error terms of (1) and (2) are uncorrelated with each other, have zero means, and have covariance matrices given by Q and 1, respectively. These covariance matrices are central to the estimation method. Whereas ordinary least squares regression finds parameter estimates by minimizing the sum of squared deviations between the fitted and observed values of ***y***, the fact that some of the dependent variables in a MIMIC model are unobserved makes this impossible (Gao and Shonkwiler; Bollen). Therefore, estimates of the model parameters are found instead by minimizing the difference between the sample covariance matrix of observed variables (**S**) and a fitted covariance matrix (**E**(**2**)) for a parameter vector, **2** (see Bollen, Browne, and Ivaldi, *et al*.).

With respect to the U.S. / Canadian demand comparison, there are two latent variables: "quality" and "information." A set of indicator equations is included in each demand model using the times series and cross-sectional data for the U.S. and Canada. Within each set of indicator equations, one equation is always required to scale the latent variable, while the other(s) identify its value.

In the time series model, the first set of indicators are intended to reflect product quality. Assuming retail produce markets are competitive, the first indicator consists of residual variation in the retail-farm margin after demand and cost are factored out. The “relative price spread” model of Wohlgenant and Mullen maintains that, in a competitive market, the retail-farm price spread will be more than simply a markup over costs. Rather, margins are determined by retail demand, farm supply, and the demand for marketing services. Including each of these in a simple empirical margin model leads to:

$$m_i = \beta_1 p_i^r + \beta_2 p_i^r q_i + \beta_3 c_i + \Lambda_{i,m} K_i + \epsilon_{i,m}, \qquad (3)$$

where m_i is the retail-farm margin of product i, p_i^r is its retail price, q_i is the quantity sold, c_i is an index of marketing-input prices, and $\epsilon_{i,m}$ is a vector of independent, identically distributed errors. Marketing cost consists of grocery-store wages as labor comprises the dominant share of operating expenses for retail grocery chains. By our hypothesis, retail margins also depend on the average level of quality for fresh produce, given by the latent variable K_i. For one of the fresh product categories, $\Lambda_{i,m}$ is normalized to 1.0 in order to scale and identify the latent quality variable. Using the margin equation to scale the latent variables means that quality is measured in the same units as margins, or dollars per pound. Conveniently, therefore, each K represents the dollar value of each incremental level of quality, whether measured by grade or another subjective assessment.

With this interpretation, each equation of the structural model for quality in the time-series model can be interpreted as a price-dependent Lancaster-Ladd input demand equation wherein each cause variable determines the aggregate demand for quality. Following Goldman and Grossman, variation in the demand for quality among households depends upon their socioeconomic attributes. Therefore, the demand for quality becomes:

$$K_i = \gamma_{10} + \sum_l \gamma_{li} Z_{li} + \xi_i, \tag{4}$$

where the vector ***Z*** of cause variables includes the average level of income, educational achievement, hours of overtime, number of children per household, and the proportion of food spending on meals away from home.

In the panel data model, regional variations in household characteristics may explain regional variations in price, reflecting underlying differences in quality. Specifically, price is a function of household income, household income squared, and family size, and are represented by Z_m:

$$\ln p_i = \alpha_0 + \sum_m \alpha_m Z_m + \Lambda_K K + \epsilon_i \tag{5}$$

Again, 7_K is normalized to 1.0 in one of the product models. Therefore, adjusted prices play the same role in the panel data model as adjusted margins do in the time-series model. Factors which may further explain household demand for quality are directly tested using the structural equation, which is similar in form to (4).

In the time-series data, measures of "healthy eating" like the ratio of low-fat to whole milk and fresh fruit's share in total food expenditure are used to identify the latent information variable. Similarly, Gao and Shonkwiler show that per capita consumption of skim milk relative to whole milk is a good indicator of the trend toward diets with lower fat. We also include the ratio of chicken consumption to red meat in order to capture this same type of dietary choice without the confounding influence of other dietary problems associated with milk products (lactose intolerance), thereby producing a set of information measurement equations:

$$y_k = \beta_{1k} x_k + \Lambda_{k,I} I + \epsilon_{i,k}, \tag{6}$$

In the structural model for information, we capture the fundamental causes of the latent information variable. These include the level of aggregate spending on primary and secondary education and another information index variable constructed similar to the one used by Brown and Schroeder. Specifically, we count the number of articles referring to the health benefits of fruit and vegetable consumption appearing in a large set of health-related academic journals abstracted by *Medline*. With these two cause variables, we write the single structural equation for information as:

$$I_i = \gamma_{20} + \sum_k \gamma_{2k} Z_{ki} + \xi_i, \tag{7}$$

where Z is the vector of cause variables similar to those described above for the aggregate time series structural model for quality.

In the panel data model, we use a similar set of indicators, including total produce consumption and educational expenditures, as indicators of consumer knowledge of the health benefits of a diet rich in fruits and vegetables. The exogenous variables (***x***) entering these indicator equations include demographic variables and an index measure of available dietary information on fruit and vegetable consumption constructed using the *Reader's Guide to Periodicals*. These measurement (indicator) equations take on the same general form given in (6). The cause variables appearing in the structural equation for information, which is similar in form to (7), include measures on the size of the minority population in a region and expenditures on food away from home. After estimating the MIMIC model with these structural and measurement components, we then use the implied latent quality and information indices in second-stage fresh produce demand equations.

For the time-series demand system, we use a variant of the Almost Ideal Demand System (AIDS) model of Deaton and Muellbauer. We test the maintained hypothesis of price exogeneity against an inverse AIDS alternative (IAIDS) and fail to reject the direct alternative (Eales and Unnevehr; Moschini and Vissa; Richards and Patterson). Further, there is some question that demand variables in the aggregate, time-series model may be cointegrated. Using the Augmented Dickey-Fuller test for cointegration, however, we reject the hypothesis of no cointegration so estimate a linear approximate version of the AIDS model in first differences.

For our purposes, the demand system consists of fresh fruit, fresh vegetables, processed fruit, processed vegetables, cereals and grain products, meat and poultry, fats and oils, dairy products, and all other food. Because we model only food demand, the system is conditional on total category expenditure and uses Moschini's corrected Stone's quantity index. Further, we apply the restrictions implied by utility maximization, namely: (1) symmetry, (2) homogeneity, and (3) adding up, by imposing them directly on the LA/AIDS parameters. With these restrictions, all elasticities are calculated using the expressions appropriate to the LA/AIDS defined by Chalfant. The information and quality indices are included as "translating," as opposed to "scaling" variables, which means that they serve to shift the demand intercept and not the equation slopes. Finally, we allow the demand for each product to follow an autoregressive process to account for habits in consumption, learning and inertia so that the share equations become:

$$w_{it} = \sum_m \theta_m w_{i,t-m} + (\alpha_{i0} + \alpha_{iI} I_t + \alpha_{iK} K_t) + \sum_j \gamma_{ij} \ln p_{jt} + \beta_i \ln(X/P)_t + \epsilon_{it}, \qquad (8)$$

where **2**, is a vector of autoregressive parameters, *I* is the latent information variable, *K* is the latent quality index, *P* is the Stone's price index, and , is a random error term.

In evaluating the effect of information and quality on fruit and vegetable demand using the panel model, we use a double logarithmic quantity-dependent demand specification. Because our objective is to explain differences in the total demand for fruits and vegetables, we aggregate across all fresh fruit and vegetable items purchased in the regions defined for each country on a weekly basis and estimate the following equation for each country:

$$\ln q_{it} = \beta_0 + \beta_1 \ln p_{it}^r + \sum_j \beta_{2j} \ln P_{jt}^r + \beta_3 \ln X_t + \beta_4 I_t + \beta_5 K_t + \epsilon_{it}, \qquad (14)$$

where q_{it} is the total quantity of fruit or vegetables purchased per capita, p_{it}^r is the price of fruits or vegetables measured as a weighted average of all the products purchased, P_{jt}^r are prices of substitute and complementary products in demand, X_t measures weekly expenditures on produce, and I_t and K_t are the latent information and quality variables. The panel data do not provide information on the purchases of other food products nor are these data available from other sources. Therefore, we can not estimate a complete food demand system, as in the aggregate, time series analysis.

Data Description and Estimation Methods

At the core of the aggregate, time series data are the per capita consumption and price data. Per capita consumption values for the U.S. are from the USDA (USDA-ERS) for a sample period of 1970 - 1999, while Canadian consumption data for this period are from Statistics Canada (Canada Food

Stats). Because Statistics Canada does not report french fry consumption as processed vegetables, but rather in terms of their fresh equivalent, we combined fresh and processed vegetables for Canada. Similarly, Statistics Canada does not provide a detailed breakdown for processed fruits in a manner similar to the USDA, so we combined fresh and processed fruit in Canada as well. Prices for the U.S. are national average indices for "all urban consumers"from the Bureau of Labor Statistics (BLS) and Canadian prices are from the Statistics Canada "Canada Food Stats" CD data product. All prices are expressed in terms of annual indices with 1992 serving as the base year. Wages for grocery store workers in the U.S., which serves as our measure of grocery store costs, is from the BLS as well, while Statistics Canada provides an equivalent measure for Canadian grocery store workers. All socioeconomic variables for Canada are from Statistics Canada's *CANSIM 2* project, while equivalent measures from the U.S. are from the Bureau of Economic Analysis. Although earlier data are available on special request, the length of our time-series was limited by the availability of data for many of the socioeconomic and demographic variables for both the U.S. and Canada. To create an indicator of produce quality, we define marketing margins for both countries. For the U.S., we use USDA reported grower prices to construct weighted average indices of retail - farm margins for each product in the fresh fruit and vegetable indices. For Canada, however, similar series of grower prices do not exist. Moreover, Canada imports most of its fresh produce throughout the marketing year. Therefore, we define marketing margins in Canada as the retail price less the average reported import unit value for that product.

The panel data model uses relatively high frequency, retail-scanner data. In order to incorporate regional socioeconomic data, the scanner data are aggregated from a store-level to a regional-level on a weekly basis for the year 2000. For the U.S. model, the data are provided by FreshLook Marketing of Chicago, Illinois. Sales by grocery retailers are available on 35 fresh fruit and 51 fresh vegetable products for eight regions in the United States (Great Lakes, Midsouth, Northeast, Plains, South Central, Southeast, West, and California) and account for approximately 90 percent of the retail sale of produce in these regions. Prices for other food products were obtained from the Bureau of Labor Statistics. Regional sociodemographic variables are developed using state-level data available from the 2000 U.S. census. Data on retail grocery and restaurant sales were used to develop a weekly measure of away from home food consumption expenditures.

The Canadian retail panel data, supplied by A.C. Nielsen Canada, provides sales on 71 fruit products and 107 vegetable products from six regions defined as individual provinces or combinations of provinces–Alberta, British Columbia, Ontario, Quebec, the Maritime provinces (Newfoundland, Prince Edward Island, Nova Scotia, and New Brunswick), and a combination of Manitoba and Saskatchewan. Like the U.S. data vendor, A.C. Nielsen Canada also achieves approximately 90 percent account coverage and develops weekly projections for each region. Only sales data on fruits and vegetables are available in this sample, therefore we use price indices of substitute food products available from Statistics Canada's *CANSIM* 2 data base, which are available on a monthly basis for each region. A cubic spline extrapolation technique is used to develop weekly measures of these variables for use with the scanner data. The *CANSIM* database also provides regional socioeconomic measures used in the measurement and structural equations for quality and information. These data, which measure regional characteristics, like population, women's participation in the workforce, the presence in children of children in the household, are only available on an annual basis.

We estimate each demand model using a two-stage procedure. In the first stage, the MIMIC model is estimated in order to provide fitted index values for both quality and information latent variables. Each of these indices is then substituted into the second-stage demand models. Both the aggregate and panel data MIMIC models are estimated with maximum likelihood methods using the Amos software package (SmallWaters Corporation). In the following section, we describe and interpret the results for each.

Results and Discussion

Based on the aggregate data for each country, Canadians consume 414 pounds per capita on average over the sample period, while Americans consume only 274 pounds. However, this comparison is misleading due to the differences in how the data are recorded in the two countries. Such discrepancies in comparisons are not encountered, however, when comparing the sale of produce in each country using the panel data. Indeed, these data allow us to literally compare apples to apples and oranges to oranges, providing several noteworthy differences. For example, the apparent annual per capita consumption of bananas in the U.S. and Canada are 13.6 and 27.6 pounds, respectively. The relative consumption rates were 7.1 versus 15.1 for apples and 5.8 versus 13.0 for oranges. Explaining these differences in consumption, however, requires more formal statistical analysis to control for other intervening factors.

In the first stage of the time series analysis, we estimate a MIMIC model wherein produce quality and information regarding the health implications of eating fruits and vegetables are both latent variables. Although the general structures of the U.S. and Canadian models are the same, they differ slightly due to differences in data availability, variable measurement and variable definition. For the

U.S., quality, the quality measurement equations consist of relative price spread specifications (Wohlgenant and Mullen). As table 1 shows, the two (non-scaled) factor-loading coefficients for quality are positive and significant, so the measurement component does an adequate job of identifying latent quality. In terms of information, the indicators consist of the ratio of low fat to whole milk, the amount of primary and secondary education spending per capita, and the budget share of fresh fruit. Fixing the education coefficient to 1.0, which is required in order to identify the information latent variable, table 1 again shows that the factor loading coefficients are positive and significant. The causal equation for quality consists of the proportion of women in the workforce, the proportion of food expenditure on meals taken away from home and the proportion of the total number of children who are less than five years old. Whereas the proportion of women in the workforce and the percentage of children under five years old lead to higher quality, more meals taken away from home lead to lower quality on an aggregate level. For the information latent variable, table 1 shows that the higher our index of fruit and vegetable health-article dissemination, the greater the level of information, which is as expected. While similar in structure, the results from the Canadian MIMIC model differ substantially.

The results in table 1 show that vegetable margins serve as the only statistically significant indicator of produce quality in the Canadian MIMIC model. Although vegetable unit values load positively on quality, fruit unit values have a negative effect, albeit both of these variables at a low level of statistical confidence. With respect to information, on the other hand, the ratio of low fat to whole milk proves to be an excellent indicator as it has a highly significant loading coefficient. On the other hand, few of the other indicators – the ratio of chicken consumption to total meat consumption, and the budget shares of fruit and vegetables – are reliable indicators of information. With respect to cause variables, both the article index and the proportion of women in the work force have a positive impact on information, although the index coefficient is not statistically significant at conventional levels. In the quality structural equation, per capita education expenditure and the proportion of young children explain a large amount of the variation in quality, while income and the proportion of food consumed away from home are less important. Although the Canadian MIMIC model does not appear to perform as well as the U.S. model, the ultimate test is how each latent variable contributes to explaining variation in produce demand over time.

Table 2 provides the elasticity of demand estimates for the U.S. data, while table 3 contains the same information for the Canadian model. For both models, we are particularly concerned here with the elasticity with respect to own price, total food expenditure and, of course, the latent quality and information variables. The results for the U.S. show that all food groups are relatively price-inelastic. More importantly, the elasticity results in table 2 show that, in the U.S., only processed vegetables respond in a positive way to higher values of the quality index over time. This is perhaps not surprising given the way that we have defined quality here. Defining quality in terms of retail-farm margins tends to capture the effect of value-added activities on perceived quality. Consumption of each fruit and vegetable category, however, rises in the level of information. Whereas consumers have long known of the health implications of fruit ("...an apple a day..."), recent media campaigns tend to focus on vegetables as a good source of a wider variety of anti-oxidants and micro nutrients that are essential to healthy diets. Notice, however, that all food categories except the excluded fats and oils group, respond positively to health information, suggesting that fatty foods have borne the brunt of the substitution toward healthy eating.

Table 3, on the other hand, provides some answers to the question of why Canadians apparently consume more fresh produce than Americans. These results show many similarities to the U.S. estimates, but also point to some critical differences. First, both fruits and vegetables are very price inelastic. Second, and most importantly, fruit consumption increases in the quality latent variable, and with an elasticity that is relatively high compared to other estimated parameters. If fresh fruit is costly to import, with lengthy inspection, long transport routes and expensive refrigeration technology, we expect that only the best quality fruit is sent to export markets. This is consistent with commonly understood practice in industry. Therefore, given that Canada produces a relatively small fraction of its fresh fruit needs, the average quality level is likely to be higher than in the U.S. However, this result does not carry through to the vegetable case. Rather, information tends to be more important in increasing vegetable consumption in Canada. This effect is similar in direction to the U.S., but somewhat lower in magnitude. Nonetheless, given the intensity of the "Reach for It" campaign in Canada, it may be the case that although the elasticity value is lower, the underlying information variable is rising at a faster rate. This would go a long way toward explaining observed consumption trends in Canada relative to the U.S., but requires corroboration to be completely convincing.

As in the time series analysis, we first estimate the MIMIC model and then estimate the demand model with the fitted quality and information variables. Furthermore, for both the U.S. and Canadian panel data models, we found it necessary to estimate the latent constructs for quality and information independently. The results from these models are discussed first, followed by a discussion on the role the quality and information play in demand.

Similar MIMIC models are used for each country and their structures resemble those used in the time series data analysis. For each country, the quality measurement model consists of hedonic model specifications where variations in fruit and vegetables prices, used as indicators of quality, are explained by household income and family size (table 4). The latent quality variable coefficient is normalized to 1.0 in the fruit (vegetable) price equation for the U.S. (Canada), but the factor loading coefficient is positive and significant in the other price equation, suggesting that the hedonic models serve as a good indicator for quality. The results for the structural equation show that quality is in turn positively related to the presence of children in the household, but negatively related to increased workforce participation by women in the U.S.

Two indicators of information or knowledge of the dietary health benefits of produce consumption are used in the U.S. and Canadian models. Like the time series model, educational expenditure (per pupil) is used as a knowledge indicator. Educational expenditures are found decline in the number of college graduates in a region, but rise with income in the U.S. The latent information variable coefficient is normalized to 1.0 in this equation for the U.S., but is unrestricted in the other indicator equation, where the total pounds of produce sold per capita serves as an indicator of dietary health information. As expected, information also has a positive and significant impact on produce consumption (table 4). In general, these results show that the MIMIC models used to identify the latent quality and information constructs are very similar for the U.S. and Canada. What remains to be seen is the role these variables play in product demand in each country.

The fit of all the product demand models is relatively good, as indicated by the high coefficient of determinations, ranging from 0.80 to 0.89. Furthermore, the signs of the estimated parameters are as expected based on theory. Each model has significant, negative own-price coefficients and positive, significant expenditure coefficients, all of which may be interpreted as elasticities in this double-log specification. The pattern of these elasticities is quite similar across countries, as well. With price and expenditure elasticities similar across each country, differences in consumption may be related to the influence of quality and information. Since, the demand variables were estimated using fitted quality and information variables, these variables are also specified in log form. As in the time series analysis, table 5 shows that quality does not have a significant effect on fresh fruit or vegetable demand in the U.S. Quality, though, has a significant and strong effect on fruit demand in Canada, as was found in the time series analysis. Similarly, information is found to have a significant, positive effect on vegetable demand in the U.S. So while changes in prices or incomes in the U.S. may not induce substantial changes in vegetable consumption, information such as that provided by the 5-A-Day campaign may play a significant role in supporting vegetable demand. Information also plays a significant role in promoting fruit consumption in Canada. However, vegetable demand is adversely affected by both quality and information in Canada. Given the way quality was measured, the negative effect on vegetable demand may partly reflect a confounding price effect. However, information was found to have a similar negative effect on fruit demand in Canada in the time series model.

Conclusions and Implications

This research seeks to explain the source of the observed difference in fruit and vegetable consumption between the U.S. and Canada. Despite their demographic and socioeconomic similarity, Canadians consume far more servings of fruits and vegetables each day compared to their U.S. counterparts. Indeed, this was confirmed using information on product sales in each country. Because prices tend to be higher in Canada, and incomes lower, we hypothesize that this difference in consumption levels is due in large part to latent, or unobserved, superior quality of imported Canadian produce. Canadian produce is felt to be of higher quality due to the fact that high transport costs can only justify importing relatively high unit-value products, or the Alchian-Allen effect.

We test the Alchian-Allen hypothesis by estimating models of fresh produce consumption that account for as many other explanations for the observed difference in U.S. and Canadian produce consumption as possible and then test for the independent effect of quality. Because quality and another important factor, "information," are unobserved, we estimate a MIMIC model of fruit and vegetable consumption that includes both quality and information as latent variables. We then use the implied values of the latent variables as explanatory variables in models of produce demand and test their impact on fruit and vegetable consumption, holding constant the potentially confounding impacts of price and expenditure differences between the two countries. This analysis was performed using time series data and a pooled, cross sectional panel data set made up of weekly observations during a one-year period for regions in each country.

Our results show that quality explains very little of the trend in fruit and vegetable consumption over time or by region in the U.S., whereas information has exerted a large and statistically significant, positive impact on consumption. Information also plays a significant role in explaining regional vegetable consumption. In Canada, information has been responsible for much of the rise in vegetable consumption over time, but has had no impact on fruit consumption. Using supermarket scanner data for the year 2000, we find that information has a significant positive effect on fruit demand. Much of the advantage Canadians enjoy in fruit consumption does indeed appear to derive from the higher average quality of fruit imported by, and consumed in, Canada. Consequently, our primary hypothesis in this paper enjoys only limited support in the aggregate, time-series and pooled data sets, but does appear to be perhaps one factor among many that could potentially explain the discrepancy in consumption levels. This finding constitutes strong evidence in favor of an Alchian-Allen effect governing Canadian fruit and vegetable imports and, hence, consumption.

The implications of this research for academic, public policy and commercial interests are many. Given their mandate to promote fruit and vegetable consumption, public health officials at the NCI and allied state health agencies will appreciate the information we provide on the factors influencing fruit and vegetable consumption. Understanding the role of information in increasing fruit and vegetable consumption will aid in designing more effective programs currently and, given the prospect for expanded funding, more effective programs in the future. Enhanced program effectiveness has direct and indirect benefits for consumers as well in terms of improved health through better information and more incentives to purchase and consume higher quality produce. Higher consumption levels clearly has a direct impact on grower revenue, as well. Moving from the current estimated consumption level of about 3.5 servings per day to the 5 a Day goal, would result in a 30 percent increase in shipments for growers. Other participants in the marketing channel would benefit from this growth in volume, including shippers, marketing agents, and retailers. These agents too are investors in the 5 a Day program and would also benefit from an improved use of their funds in this effort.

References

Adejala, A.O., R.M. Nayga, and T.C. Lauderbach. "Income and Racial Differentials in Selected Nutrient Intakes." *American Journal of Agricultural Economics*, 79(1997):1452-1460.

Alchian, A. and R. Allen. *Exchange and Production: Competition, Coordination, and Control*. 3rd ed. Wadworth Publishing Co., Belmont, California, 1983.

Alston, J.M., J.A. Chalfant, J.E. Christian, E. Meng, N.E. Piggott. *The California Table Grape Commission's Promotion Program: An Evaluation*, Research Report, Department of Agricultural Economics, University of California, Davis, July 1996.

Amemiya, T. "Regression Analysis When the Dependent Variable is Truncated Normal." *Econometrica*, 41(1973):997-1016.

Anderson, T. W. "Linear Latent Variable Models and Covariance Structures." *Journal of Econometrics* 41(1989): 91-119.

Barten, A.P. "Consumer Allocation Models: Choice of Functional Forms." *Empirical Economics*, 18(1993):129-158.

Block, G., B. Patterson, and A. Subar. "Fruit, Vegetables, and Cancer Prevention: A Review of the Epidemiological Evidence." *Nutrition and Cancer* 18(1992): 1-29.

Bollen, K. *Structural Equations with Latent Variables*. New York: John Wiley and Sons. 1989.

Browne, M. W. "Asymptotically Distribution-Free Methods for the Analysis of Covariance Structure." *British Journal of Mathematical and Statistical Psychology* 37(1984): 62-83.

Bucklin, R. E. and S. Gupta. (1992) "Brand Choice, Purchase Incidence, and Segmentation: An Integrated Approach." *Journal of Marketing Research* 29: 201-215.

Bucklin, R. E. and J. M. Lattin. (1991) "A Two-State Model of Purchase Incidence and Brand Choice." *Marketing Science* 10: 24-39.

Bucklin, R. E., S. Gupta, and S. Han. (1995) "A Brand's eye view of Response Segmentation in Consumer Brand Choice Behavior." *Journal of Marketing Research.* 32: 66-74.

Capps, O. Jr., S.-C. Seo, and J. P. Nichols. (1997) "On the Estimation of Advertising Effects for Branded Products: An Application to Spaghetti Sauces." *Journal of Agricultural and Applied Economics* 29: 291-302.

Chang, H. S. and H. W. Kinnucan. "Advertising, Information, and Product Quality: The Case of Butter." *American Journal of Agricultural Economics* 73(1991): 1195-1203.

Clemens, L.H., D.L. Slawson, R.C. Kleges. "The Effect of Eating Out on Quality of Diet in Premenopausal Women." *Journal of the American Dietetic Association* 99(1999):442-444.

Cox, T. L. and M. K. Wohlgenant. "Prices and Quality Effects in Cross-Sectional Demand Analysis." *American Journal of Agricultural Economics* 68(1986):908-919.

Davis, G.C. and W.J. Hewitt. "Measuring the Quality of Imported Tobacco." Journal of Agricultural and Applied Economics, 28(1996):148-158.

Deaton, A. and J. Muellbauer. *Economics of Consumer Behavior*. Cambridge University Press, Cambridge, U.K.

Feick, L F., R. O. Herrmann, and R. H. Warland. "Search for Nutrition Information: A Probit Analysis of the Use of Different Information Sources." *Journal of Consumer Affairs* 20(1986): 173-192.

Foltz, T. "Senator Seeks Report on Program's Support." *The Packer*, p. A3, July 19, 1999.

Frazão, E. "High Costs of Poor Eating Patterns in the United States," in *America's Eating Habits: Changes and Consequences,* E. Frazão, ed., Food and Rural Economics Division, Economic Research Service, U.S. Department of Agriculture. Agriculture Information Bulletin No. 750 (AIB-750), 1999.

Gao, X. M. and J. S. Shonkwiler. "Characterizing Taste Change in a Model of U.S. Meat Demand: Correcting for Spurious Regression and Measurement Errors." *Review of Agricultural Economics* 15(1993): 313-324.

Gao, X. M., E. J. Wailes, and G. L. Cramer. "A Microeconometric Analysis of Consumer Taste Determination and Taste Change for Beef." *American Journal of Agricultural Economics*, 79(1997):573-582.

Gardner, B. "The Farm-Retail Price Spread in a Competitive Food Industry." *American Journal of Agricultural Economics* 57(1975): 399-486.

Gertler, P. J. "A Latent-Variable Model of Quality Determination." *Journal of Business and Economic Statistics* 6(1988): 97-104.

Goldman, F. and M. Grossman. "The Demand for Pediatric Care: An Hedonic Approach." *Journal of Political Economy*; 86(1978):259-280.

Gould, B. W. and H. C. Lin. “Nutrition Information and Household Dietary Fat Intake.” *Journal of Agricultural and Resource Economics* 19(1994): 349-365.

Granger, C. and P. Newbold. “Spurious Regressions in Econometrics.” Journal of Econometrics 2(1974): 111-120.

Green, R. D., and J. Alston. "Elasticities in AIDS Models." *American Journal of Agricultural Economics,* 72(1990): 442-45.

Grossman, M. “The Correlation Between Health and Schooling.” in *Household Production and Consumption* ed. N. E. Terlecky. New York: Columbia University Press, 1975. pp. 147-211.

Grossman, M. and R. Kaestner. “Effects of Education on Health.” Paper presented at *Social Benefits of Education: Can They be Measured?* Conference, Washington, D.C. 1985.

Heien, D. and C.R. Wessels. “Demand Systems Estimation with Microdata: A Censored Regression Approach.” *Journal of Business and Economic Statistics*, 8(1990):365-71.

Huang, K. S. *U.S. Demand for Food: A Complete System of Quantity Effects on Prices* Economic Research Service - USDA. Tech. Bull. No. 1795. July, 1991.

Ippolito, P.M. “Information, Advertising, and Health Choices: A Study of the Cereal Market.” *Rand Journal of Economics*, 21(1990):459-480.

Ippolito, P.M. and A.D. Mathios. “Information and Advertising: The Case of Fat Consumption in the United States.” *American Economic Review,* 85(1995):91-95.

Ivaldi, M., S. Monier-Dilhan, and M. Simioni. “Stochastic Production Frontiers and Panel Data: A Latent Variable Framework.” *European Journal of Operational Research* 80(1995): 534-547.

Jensen, H. H., and T. Kesavan. “Sources of Information, Consumer Attitudes on Nutrition, and Consumption of Dairy Products.” *Journal of Consumer Affairs* 27(1993): 357-376.

Jensen, H. H., T. Kesavan, and S. R. Johnson. “Measuring the Impact of Health Awareness on Food Demand.” *Review of Agricultural Economics* 14(1992): 299-312.

Jensen, H. H., and J. R. Schroeter. (1992) “Television Advertising and Beef Demand: An Econometric Analysis of “Split-Cable” Household Panel Scanner Data.” *Canadian Journal of Agricultural Economics* 40: 271-294.

Johnson, G. “Numbers Continue to Rise.” *The Packer*, December 29, 1997.

Joreskog, K. G. and A. S. Goldberger. “Estimation of a Model with Multiple Indicators and Multiple Causes of a Single Latent Variable.” *Journal of the American Statistical Association* 75(1975): 631-639.

Kamakura, W. A. and G. J. Russel. (1989) “A Probabalistic Choice Model for Market Segmentation and Elasticity Structure.” *Journal of Marketing Research* 26: 379-390.

Kenkel, D.S. “Health Behavior, Health Knowledge, and Schooling.” *Journal of Political Economy*, 99(1991):287-305.

Keller, W.J.; van Driel, J. “Differential Consumer Demand Systems.” *European Economic Review*; 27(1985):375-390.

Kim, S.Y., R. Nayga, O. Capps, Jr. “The Effect of Food Label Use on Nutrient Intakes: An Endogenous Switching Regression Analysis.” *Journal of Agriculture and Resource Economics*, forthcoming, 2000.

Kinnucan, H.W., H. Xiao, C.J. Hsia, and J.D. Jackson. “Effects of Health Information and Generic Advertising on U.S. Meat Demand.” *American Journal of Agricultural Economics,* 79(1997): 13-23.

Lin, B.H., J. Guthrie, and E. Frazão. “Nutrient Contribution of Food Away from Home,” in *America's Eating Habits: Changes and Consequences,* E. Frazão, ed., Food and Rural Economics Division, Economic Research Service, U.S. Department of Agriculture. Agriculture Information Bulletin No. 750 (AIB-750), 1999.

Maddala, G.S. Limited-Dependent and Qualitative Variables in Econometrics, Cambridge: University Press, 1983.

McCraken, V.A. “The U.S. Demand for Vegetables,” in *Vegetable Markets in the Western Hemisphere: Trends, Policies, and Trade Linkages*, R.A. Lopez and L.C. Polopolus, eds., Ames, Iowa: Iowa State University, 1992.

Moorman, C. and E. Matulich. “A Model of Consumers’ Preventative Health Behaviors: The Role of Health Motivation and Health Ability.” *Journal of Consumer Research* 20(1993): 208-228.

Morgan, K. J. “Socioeconomic Factors Affecting Dietary Status: An Appraisal.” *American Journal of Agricultural Economics* 68(1986): 1240-1245.

Offner, J. "Canadians Eat 4 Servings a Day." *The Packer*, p. C6, July 19, 1999.

Park, J. L. and O. Capps, Jr. "Demand for Prepared Meals by U.S. Households." *American Journal of Agricultural Economics* 79(1997): 814-824.

Patterson, Paul M. and Timothy J. Richards. "Newspaper Advertisement Characteristics and Apple Variety Attraction: A MIMIC Model Approach." *Agribusiness: An International Journal*, In print, 1999.

Putnam, J.J. and J.E. Allshouse. *Food Consumption, Prices, and Expenditures, 1970-97*, Food and Rural Economics Division, Economic Research Service, U.S. Department of Agriculture. Statistical Bulletin No. 965, 1999.

Richards, T.J. "Dynamic Model of Fresh Fruit Promotion: A Household Production Approach." *American Journal of Agricultural Economics*, 81(1999):195-211.

Richards, T.J., and X.M. Gao, and P.M. Patterson. "Advertising and Retail Promotion of Washington Apples: A Structural Latent Variable Approach to Promotion Evaluation." *Journal of Agricultural and Applied Economics*, 31(1999):15-28.

Scott, Debra. The Research Department. Seattle, WA. Personal communciation, September, 1998.

SmallWaters Corporation. *Amos Users' Guide: Version 3.6*. Chicago, IL, 1997.

Statistics Canada. Agriculture Division. *Food Consumption in Canada: Part II, 1998*. Ottawa, Canada, 1998.

Statistics Canada. *Canada Food Stats, 2001*. Ottawa, Canada, 2002.

Statistics Canada. *CANSIM II*. http://cansim2.statcan.ca/cgi-win/cnsmcgi.exe? CANSIMFile= CII/CII_1_E.HTM&RootDir=CII/) Ottawa, Canada. May 2002.

Theil, H. *Theory and Measurement of Consumer Demand*, vol. 1. Amsterdam: North-Holland Publishing Co., 1975.

United States Department of Agriculture. Economic Research Service. (http://www.ers.usda.gov/ data/foodconsumption/ datasystem.asp). Washington, D.C. May 2002.

United States Department of Commerce. Bureau of Economics Analysis. http://www.bea. doc.gov/ bea/dn/nipaweb/index.asp). Washington, D.C. May 2002.

United States Department of Labor. Bureau of Labor Statistics. http://data.bls.gov /cgi-bin/ dsrv?cu). Washington, D.C. May 2002.

Variyam, J. N., J. Blaylock, D. Smallwood, and P. P. Basiotis. "USDA's Healthy Eating Index and Nutrition Information." Food and Rural Economics Division, ERS-USDA. Tech. Bull. No. 1866.

Verhovek, S.H. "Growers' Lament: The Crop's Bright Red, but So Is the Ink." *New York Times*, p. 18, October 26, 1999.

Waterfield, L. "Canada a Hungry Market." *The Packer*, p. A1-A2, November 17, 1997.

Waterfield, L. "Groups Ask Cancer Institute for $25 Million Funding Hike." *The Packer*, p. A3, May 17, 1999.

Wohlgenant, M. K., and J. D. Mullen. "Modeling the Farm-Retail Price Spread for Beef." *Western Journal Agricultural Economics.* 12(1987): 119-1259.

Zoumas-Morse, C., C.L. Rock, E.J. Sobo, M.L Neuhauser. "Children's Pattern of Macronutrient Intake and Association with Restaurants and Home Eating." *Journal of American Dietetic Association* 101(2001):923-925.

Table 1. MIMIC Model Estimates for U.S. and Canada - Time Series Analysis.

		U.S.		Canada	
Equation	**Variable**	**Estimate**	**t-ratio**	**Estimate**	**t-raio**
Quality	Women in Workforce	0.049	1.446		
Quality	Food Away from Home	-0.367	-1.661	0.001	0.682
Quality	Children < 5 yrs.	0.782	2.948	0.073	51.479
Quality	Educ. Expend.			1.048	70.053
Quality	Earnings			-0.001	-1.130
Fruit Margin[1]	Fresh Fruit Exp.	-0.394	-4.072	0.000	0.298
Fruit Margin	Grocery Cost	0.173	0.710	-0.023	-1.464
Fruit Margin	Quality (latent)	1.000		1.000	
Proc. Fruit Margin	Proc. Fruit Exp.	-0.079	-0.509		
Proc. Fruit Margin	Grocery Cost	0.821	8.451		
Proc. Fruit Margin	Quality (latent)	0.329	4.255		
Veg. Margin[2]	Fresh Veg. Exp.	-0.405	-14.726	0.003	0.450
Veg. Margin	Grocery Cost	-0.098	-0.398	0.264	1.639
Veg. Margin	Quality (latent)	2.006	5.991	0.328	2.215
Fruit Unit Value	Quantity of Fruit			-0.023	-0.289
Fruit Unit Value	Quality (latent)			-0.015	-1.597
Vegetable U.V.	Quantity of Veg.			-0.033	-0.377
Vegetable U.V.	Quality (latent)			0.005	1.200
Information	Fat:Carbo Calorie Ratio	-0.025	-0.972		
Information	Article Index	0.468	2.674	0.124	1.065
Information	Per Cap. Weekly Earnings	-0.160	-2.435		
Information	Women in Workforce			0.370	5.787
Milk Ratio	Information (latent)	1.978	2.757	1.009	104.672
Chicken Ratio	Information (latent)			-0.132	-0.324
Education Exp.	Information (latent)	1.000			
Fruit Share[3]	Quantity of Fruit			-0.014	-0.220
Fruit Share	Information (latent)	1.694	2.691	0.058	0.419
Share of Veg.	Quantity of Veg.			0.001	0.346
Share of Veg.	Information (latent)			1.000	

[1] Fresh fruit margin for U.S.; fresh and processed fruit margin for Canada.
[2] Fresh vegetable margin for U.S.; fresh and processed vegetable margin for Canada.
[3] Fresh fruit share in U.S.; share of fresh and processed fruit in Canada.

Table 2. U.S. Demand Elasticities

	Fresh Fruit	Proc. Fruit	Fresh Veg.	Proc. Veg.	Meats	Dairy Prods.	Grains
Fresh Fruit Price	-0.385*	0.188	-0.105	-0.049	-0.048	-0.086*	-0.436
	-3.526	0.817	-1.439	-0.679	-0.897	-2.522	-0.688
Proc. Fruit Price	0.022	-0.360	-0.065	-0.055	-0.019	0.009	0.006
	0.378	-1.315	-1.494	-1.163	-0.593	0.298	0.095
Fresh Veg. Price	-0.182	-0.204	-0.214*	0.008	-0.089	-0.149*	-0.137
	-1.621	-0.736	-2.347	0.086	-1.294	-3.488	-1.823
Proc. Veg. Price	-0.237*	-0.293	-0.106	-0.163	-0.134*	-0.244*	-0.142
	-2.276	-1.017	-1.203	-1.340	-2.206	-5.279	-1.594
Meats Price	-0.161	0.012	-0.138	-0.033	-0.447*	-0.202*	-0.064
	-1.270	0.039	-1.301	-0.304	-5.175	-4.250	-0.699
Dairy Price	-0.253*	0.299	-0.239*	-0.175	-0.211*	-0.303*	-0.091
	-2.049	0.882	-2.181	-1.523	-2.858	-3.894	-1.233
Grains Price	-0.103	0.073	-0.131*	-0.046	-0.058	-0.097*	-0.246
	-1.412	0.293	-2.237	-0.704	-1.331	-2.421	-1.872
Exp.	0.589	1.692	0.886*	1.638*	0.933*	0.785*	1.181*
	1.243	1.564	1.982	3.651	3.250	4.811	4.037
Quality	-0.887	0.558	0.389	2.224*	0.833	1.127*	1.814
	-1.096	0.309	0.509	2.939	1.683	4.241	3.686*
Info.	0.739*	0.557	1.023*	1.213*	0.912*	1.019*	1.176*
	5.238	1.767	7.797	9.072	10.584	22.032	13.902

Values below the estimates are t-ratios. A single asterisk indicates significance at a 5% level.

Table 3. Canada Demand Elasticities

	Fruit	Vegetables	Meats	Dairy Products	Grain and Cereals
Fruit Price	-0.213*	-0.026	-0.220*	-0.055	-0.144
	-2.258	-0.483	-3.832	-0.938	-1.509
Vegetables Price	-0.149	-0.144	-0.464*	-0.086	-0.485*
	-1.323	-0.919	-5.095	-0.798	-3.630
Meats Price	-0.260*	-0.146	-0.389*	-0.006	-0.198
	-2.724	-1.629	-4.387	-0.079	-1.559
Dairy Price	-0.407*	-0.251*	-0.480*	-0.095	-0.224
	-3.183	-1.917	-4.880	-0.735	-0.993
Grain and Cereals Price	-0.123	-0.153*	-0.179*	0.080	-0.554*
	-1.053	-2.144	-2.015	0.700	-2.179
Expenditure	0.885*	1.248*	0.121	1.777*	0.392
	2.848	2.947	0.499	6.029	1.067
Quality	0.486*	-0.225	-0.058	0.216	-0.061
	1.971	-0.654	-0.294	0.930	-0.210
Information	-0.025*	0.026	-0.003	-0.030*	0.017
	-2.032	1.435	-0.347	-2.475	1.246

Values below the elasticity estimates are t-ratios. A single asterisk indicates significance at a 5% level.

Table 4. MIMIC Model Estimates for U.S. and Canada - Panel Data Analysis.

		U.S.		Canada	
Equation	**Variable**	**Estimate**	**t-ratio**	**Estimate**	**t-ratio**
Quality	HH with Children	0.731	1.892	4.291	3.766
Quality	Women in Workforce	-6.74	-2.318	0.010	1.557
Quality	Food Away from Home			9.678	6.734
Log Fruit Price	Household Income	0.937	68.708	-0.256	-11.066
Log Fruit Price	Household Income Squared	-0.011	-79.004	0.003	10.562
Log Fruit Price	Family Size	1.162	12.965	-0.402	-2.989
Log Fruit Price	Qaulity (latent)	1.000		0.280	128.990
Log Veg. Price	Household Income	0.440	27.392	-0.558	-7.523
Log Veg. Price	Household Income Squared	-0.005	-31.066	0.006	7.451
Log Veg. Price	Family Size	-0.071	-0.453	0.866	2.215
Log Veg. Price	Qaulity (latent)	3.623	2.211	1.000	
Information	Minority Population	-1.844	-7.205	-1.627	-4.030
Information	Food-Away-from-Home	30.790	37.240	0.047	
Educ. Expend.	College Graduates	-21.941	-16.798	-1.092	-1.086
Educ. Expend.	Women in Workforce	0.485	0.686		
Educ. Expend.	Income	0.509	27.705		
Educ. Expend.	Information (latent)	1.000		0.463	9.502
Produce Cons.	Black	-2.545	-11.844		
Produce Cons.	Hispanic	2.985	7.194		
Produce Cons.	Asian	-12.449	-7.079		
Produce Cons.	Income	0.036	1.481	0.144	6.978
Produce Cons.	Article Index	0.007	1.868	0.017	3.128
Produce Cons.	Information	0.201		1.00	

Table 5. Per Capita Produce Demand in U.S. and Canada - Panel Data Analysis

	U.S.		Canada	
Variable	**Fruits**	**Vegetables**	**Fruits**	**Vegetables**
Log Fruit Price	-0.672**	-0.306**	-0.860**	-0.134**
	(-13.47)	(-5.83)	(-19.00)	(-3.02)
Log Vegetable Price	-0.115**	-0.886**	-0.148**	-0.869**
	(-2.44)	(-17.86)	(-3.58)	(-21.49)
Log Meat Price	4.643**	-5.276**	1.347**	-1.414**
	(6.21)	(-6.71)	(7.72)	(-8.30)
Log Dairy Price			-1.185**	1.238**
			(-7.80)	(8.34)
Log Grain Price	-10.785**	11.246**	-0.995**	0.982**
	(-9.07)	(8.99)	(-4.31)	(4.35)
Log Processed Fruit Price	2.268**	-2.636**	0.110	0.056**
	(5.40)	(-5.97)	(0.81)	(0.42)
Log Processed Veg Price	1.464**	-1.556**	-0.707**	0.427**
	(5.30)	(-5.36)	(-3.28)	(2.03)
Log Produce Expend. per capita	1.090**	0.859**	1.132**	0.870**
	(41.07)	(30.77)	(33.66)	(26.48)
Log Quality Index	1.274	-1.625	1.224**	-1.225**
	(0.73)	(-0.88)	(6.11)	(-6.26)
Log Information Index	-0.133	0.376*	0.478**	-0.520
	(-0.64)	(1.72)	(4.30)	(-4.80)
R^2	0.86	0.80	0.89	0.84
F-Value	268.82**	179.60**	235.60	154.46

The values in parentheses are t-values; two and one asterisks denote significance at the 5% and 10% levels, respectively.