Impact of Health Information on Demand for Fats and Oils in Japan: Cointegration and A Complete Demand System Approach

Sam-Ryang Kim, Wen S. Chern and Eugene Jones*

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* Sam-Ryang Kim is an instructor in the Department of Economics, Pusan National University, Korea. Wen S. Chern and Eugene Jones are Professor and Associate Professor, respectively, in the Department of Agricultural, Environmental, and Development Economics, The Ohio State University. The research was funded by a National Research Initiative (NRI) grant sponsored by the U.S. Department of Agriculture.

Introduction

During the mid-1960's, scientists discovered a debilitating link between consumers' intake of saturated fat and their risk of coronary heart disease. Since this time, many medical and dietary studies have shown an increasing risk of coronary heart disease associated with high intakes of saturated fat and cholesterol. A most revealing U.S. government report emphasized a direct correlation among dietary intake of saturated fat, increased serum cholesterol levels, and the risk of coronary heart disease (USDHS, 1988). Consumers' knowledge of the dietary effects of saturated fat and cholesterol has expanded as health professionals and the mass media have increased the dissemination of health information. One example of this is a national cholesterol educational program launched in 1986. This program is credited with significantly advancing consumers' knowledge of the adverse health effects of fat and cholesterol. Indeed awareness of the adverse health effects of a high fat diet increased 43 percentage points (8% to 55%) over the 1970-88 period (Putler and Frazao, 1994).

Just as medical reports and other sources of health information have enhanced Americans' awareness and understanding of the dietary effects of saturated fats and cholesterol, a reasonable hypothesis is that similar reports in Japan have had comparable or parallel effects. Indeed health information needs in Japan may be even greater than those in the U.S. because of the recent influence of western culture on Japanese's food consumption patterns. Goto (1992) reports that serum cholesterol levels among the under 30 age group of Japanese is higher than it is for Americans of this same age group. This pattern evolved as the Japanese switched from eating large quantities of fish and rice to eating foods high in fats. Such diets greatly elevated heart risk disease among this age group, as evidenced by the increased mortality rate from cardiovascular diseases. The over 30 age group has not been greatly influenced by western culture and therefore has lower serum cholesterol levels than their American counterparts.

Agricultural economists have attempted to assess consumers' health concerns by examining the changing consumption patterns for fats and oils, especially vegetable oils (low in fat content) as compared to non-vegetable or animal oils (higher in fat content). Research to date in the U.S. suggests that consumers are indeed substituting vegetable oils for non-vegetable oils. Yen and Chern (1992) and Chern, et al. (1995) conducted demand studies on fats and oils consumption in the U.S. and their studies show increasing consumption of vegetable oils, but decreasing consumption of animal fats.

Given the findings of Americans' response to health information, a key issue prompting this study is that of whether the Japanese consumers are similarly influenced by health information. Consumption data show quite clearly that the Japanese are consuming more vegetable and tropical oils, and less animal fats. A relevant question, of course, is why? Is this pattern prompted by economic factors such as changing relative prices for vegetable oils and animal fats, changing tastes and preferences, economic growth, or exchange rate factors relating to oil imports? Or, is this pattern induced by non-economic factors such as the Japanese consumers' increasing concerns about the health risk of fat and cholesterol, or other socio-demographic factors? Answering such questions is the focus of this study.

U.S. policymakers find the current utilization trend of higher rapeseed imports and lower soybean imports for Japan to be quite disturbing. And while both commodities fall within the vegetable category and are used predominantly for oil, consumption growth of rapeseed oil over the past two decades has greatly exceeded that of soybean oil. Indeed the growth of rapeseed oil in the Japanese market has been so rapid that, since 1987, its use has exceeded that of soybean oil. These changes have engaged the attention of academic researchers, officials in the soybean industry, and policymakers in U.S. government as they try to identify factors causing these adverse conditions. To this end, this study examines the consumption patterns for fats and oils in

Japan, with particular emphasis on the changes induced by health concerns and information dissemination, and meat trade liberalization.

Measures of Consumer Health Information

A critical problem one faces in analyzing the impacts of health concerns associated with fat and cholesterol is that of measuring these concerns over a historical time period. Two of the first agricultural economists to integrate health concerns within a demand analysis study were Brown and Schrader(1990). These authors developed a cholesterol information index based on the numbers of published medical articles both supporting and questioning a linkage between cholesterol and arterial diseases. This index, or a slightly modified one, has been employed by Chang and Kinnucan (1991), Capps and Schmitz (1991), Yen and Chern (1992), Kim (1993) and Chern et, al. (1995). Researchers have now come to recognize the problematic nature of health indexes. While such indexes may yield high explanatory power, the information content used in their construction may not truly reflect consumers' changing health information on the demand for such foods in explaining the structural change in an empirical demand analysis.

To overcome problems related to the index constructed by Brown and Schrader, Kim and Chern (1997) attempted to construct an index that captures a more complete measure of Japanese consumers' fat and cholesterol information. The authors used more encompassing key words and a modified weighting method under the assumption that an article published in a specific time period has both carry over and decay effects. Furthermore, Kim and Chern (1998) constructed a Fat and Cholesterol Information Index for Japan using a geometrically decreasing weight function (FCIIJ-GWF) and they showed that it outperformed an ad-hoc cumulative index. Because of this improved performance, this index is also used in this study.

Methodology

In analyzing consumption patterns among the oils in Japan, we learned that soybean and rapeseed oils are blended as salad or vegetable oil and therefore separate demand parameters cannot exist for the two oils. Given this unique feature of the Japanese fat and oil market, a conceptual framework is developed to specify a two-components demand model: a derived demand model for soybean oil and rapeseed oil, and a complete demand system model for all fats and oils.

A Derived Demand Model for Soybean Oil and Rapeseed Oil

One of the objectives in this study is to investigate the market competition between soybean oil and rapeseed oil. The interesting question is whether these consumption trends have been caused by relative prices, the increasing health concern by consumers and/or supply-side factors such as meat trade liberalization.

Most oilseeds such as soybeans and rapeseeds are usually crushed to oil and meal, with the meal being used for animal feed. The oil extraction ratio of rapeseed (37%) is much higher than that of soybeans (18%), while the meal extraction ratio of rapeseed (57%) is much lower than that of soybeans (80%). That means that one ton of rapeseed yields much more oil than does one ton of soybeans. In Japan, meat trade liberalization since 1988 has induced significant decreases in domestic meat production and significant increases in total meat imports. Given the difference in meal-oil ratio between soybeans and rapeseed, this trade liberalization could have impacted the demand for soybeans.

To test hypotheses relating to meat trade liberalization, we incorporate supply-side variables such as total meat imports and/or total domestic meat production. Factors relating to the competitiveness of soybean and rapeseed oils, or more generally the competitiveness of soybeans and rapeseeds, are also integrated into the model. A most important factor, of course, is the relative exchange rate between Canada and the U.S. Other variables integrated into the model include prices of soybeans, rapeseeds, soybean meal, and rapeseed meal, and a consumers' health information variable.

The derived input demand model for soybean oil and rapeseed oil is specified as:

(1) $$q_1 = g_1\left(p_1, p_2, y, p_1^{\,s}, p_2^{\,s}, p_1^{\,m}, p_2^{\,m}, D, S\right)$$

(2) $$q_2 = g_2\left(p_1, p_2, y, p_1^{\,s}, p_2^{\,s}, p_1^{\,m}, p_2^{\,m}, D, S\right)$$

where q_1 and q_2 are the quantities of soybean oil and rapeseed oil respectively, p_1 and p_2 are real prices of soybean oil and rapeseed oil deflated by CPI for all commodities respectively, $p_1^{\,s}$

and p_2^s are real prices of soybeans and rapeseeds (oil seeds) deflated by CPI respectively, p_1^m and p_2^m are the real prices of soybean meal and rapeseed meal deflated by CPI, respectively, D is a vector of socio-demographic and health information variables, and S is a vector of supply-side variables affecting the derived demand by oil processors.

A Complete Demand Model for All Fats and Oils

This study applies a flexible demand system developed by Lewbel (1989). His model nests the Translog demand system developed by Christensen et al. (1975) and the Almost Ideal Demand System (AIDS) developed by Deaton and Muellbauer (1980), two of the most popular models as special cases. Let n be the number of goods, w_i be the budget share of good i, p_i be price of good i, x be total expenditure. Lewbel's flexible demand system in expenditure share form can be expressed as:

(3) $$w_i = \left\{ \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \log p_j + \beta_i \left(\alpha_0 + \sum_{j=1}^{n} \alpha_j \log p_j + 0.5 \sum_{j=1}^{n} \sum_{k=1}^{n} \gamma_{jk} \log p_j \log p_k \right) - \left[\sum_{j=1}^{n} \gamma_{ij} + \beta_i \left(1 + \sum_{j=1}^{n} \sum_{k=1}^{n} \gamma_{jk} \log p_k \right) \right] \log x \right\} \Bigg/ \left(1 + \sum_{j=1}^{n} \sum_{k=1}^{n} \gamma_{jk} \log p_k \right) \quad i = 1, \ldots\ldots, n.$$

Adding-up, homogeneity and symmetry conditions of the demand system require the following restrictions to be satisfied:

(4) $$\sum_{i=1}^{n} \alpha_i = 1, \quad \sum_{i=1}^{n} \beta_i = 0,$$
$$\sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} = 0, \quad \text{and} \quad \gamma_{ij} = \gamma_{ji} \qquad \text{for all } i, j$$

As a nested case, the restrictions $\sum_{j=1}^{n} \gamma_{ij} = 0$ for all i reduce the flexible demand system to the AIDS, while the restrictions of $\beta_i = 0$ for all i lead to the Translog demand system. These linear restrictions can be tested to assess the adequacy and relative explanatory power of the AIDS and Translog demand systems. The test can be performed with the Wald test based on parameter estimates and variance-covariance matrix of the Lewbel's general model.

To incorporate demographic and health information variables, this study uses demographic translating as proposed by Pollak and Wales (1978). Linear translating replaces taste change parameters $\alpha_i's$ in equation (3) by

$$(5) \qquad \alpha_i = \alpha_{i0} + \sum_{h=1}^{m} \alpha_{ih} M_h \qquad i = 1,\ldots\ldots,n \quad h = 1,\ldots..,m$$

where M_h is hth demographic or health information variable and α_{ih} is the associated coefficient in the ith share equation, and m is the number of demographic and health information variables in the system.

To allow for serially correlated errors, the first-order autoregressive scheme can be specified. The same autocorrelation parameter ρ is incorporated into each share equation and this process is consistent with work conducted by Ray (1984), and Yen and Chern (1992).

Data and Commodity Grouping

The annual aggregate consumption data for various fats and oils in Japan were collected from *the Annual Report of Fats and Oils in Japan* published by the Ministry of Agriculture, Forestry and Fishery (MAFF). Seven vegetable oils and four animal fats out of fifteen vegetable oils and six animal fats were included in this study based on the average quantity shares from 1964 to 1994. The wholesale price data for various fats and oils were also collected from *the Annual Report of Fats and Oils in Japan* published by the MAFF, while the import price data were collected from *Trade Statistics* published by Ministry of Finance in Japan. Import price data were used for some fats and oils which did not have complete series of wholesale prices.

Since soybean oil and rapeseed oil are blended in Japan, they are combined as a single oil in the complete demand system for all major fats and oils. In an empirical demand analysis, the composite commodity theorem can be used to justify this aggregation since the prices of soybean oil and rapeseed oil have been almost identical. Therefore, we may treat the blended soybean-rapeseed oil as a composite commodity by simply summing the consumption of soybean oil and rapeseed oil, and using an expenditure-share weighted price of soybean oil and rapeseed oil prices as the price for the blended salad oil.

Separate demand parameters can not be successfully estimated for several other oils, apparently due to the very high correlations of prices over the sample period. Thus, further grouping of several oils is necessary. Specifically, hog grease and beef tallow are combined and so are rice bran oil, corn oil and cottonseed oil. These two groupings are very reasonable because hog grease and beef tallow are the two most important animal fats while rice bran, corn and cottonseed are more specialty oils. Since the prices of other oils do not present any problems for estimation, we treat them as individual oils. They include palm oil, fish oil, safflower oil, and butter. All together, there are seven oil groups in the complete demand system.

Empirical Results

The Model for Soybean and Rapeseed Oils

We employed linear functions for both soybean and rapeseed oil. The estimation result from a Box-Cox model strongly supports a linear function for soybean oil. Specifically, the estimated value of the transformation parameter (Lambda: λ) in the soybean oil demand equation turned out to be close to one, implying the appropriateness for a linear function. However, the estimated value of the transformation parameter in the rapeseed oil demand equation gives no explicit guidance in selecting a functional form. Nevertheless, the linear function is used for its ease in conducting a cointegration analysis. Also, a dummy variable is incorporated into the soybean oil and rapeseed oil demand equations to identify the likely structural change caused by the 1988 meat trade liberalization.

The Dickey-Fuller (DF), Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests (Dickey and Fuller, 1979; Campbell and Perron, 1991; and Phillips and Perron, 1988) were employed to test for unit-root. The test results (not reported here) indicate that all the variables incorporated into both soybean oil and rapeseed oil demand equations are identified as integrated of order one, hence unit-root nonstationary. Furthermore, there exists cointegration relationships between the dependent variables and explanatory variables in both soybean oil and rapeseed oil demand equations based on the tests of residuals. Since a cointegration relationship among the time-series variables employed in the soybean oil and rapeseed oil demand equations is detected, the suggested model can be readily accepted as a reasonable model representing a long-run relationship among time-series variables in each demand equation. However, in the presence of serial correlation problems, the OLS estimator in the cointegration regression may be asymptotically inefficient and may have a non-standard distribution which make the usual statistical inference difficult. In order to correct possible serial correlation, the first-order autoregressive scheme can be applied to both soybean and rapeseed equations based on the method suggested by Phillips (1991).

To identify significant factors affecting the demands for soybean oil and rapeseed oil, two models with and without a correction for serial correlation were estimated. These models incorporate total meat production, total meat import, and a fat and cholesterol information index. The regression results (not reported here) indicate that the estimated parameters associated with MIMP (total meat import) have negative signs for soybean oil and positive signs for rapeseed oil, and they are statistically significant at 5% level. These results indicate that increasing meat imports, induced by meat trade liberalization since 1988, have caused an increase in the consumption of rapeseed oil and a decrease in the consumption of soybean oil. The estimated parameters concerning the fat and cholesterol information index are not statistically significant in all cases. These results imply that health risk information on fat and cholesterol as provided to the Japanese consumers has not impacted oil processors' demands for soybean oil and rapeseed oil. This finding is consistent with the fact that Japanese consumer can not distinguish soybean oil from rapeseed oil because soybean oil and rapeseed oil are usually blended to produce a salad oil (a kind of cooking oil).

The Complete Demand System for All Fats and Oils

The test results (not reported here) for unit-root nonstationarity of all the variables in the Lewbel model showed that they are all integrated of order one, with or without a drift based on the DF and PP tests. The DF, ADF and PP tests, with or without drifts, were further applied to the residuals of three Lewbel demand models. The results indicate that there exist cointegration relationships for all the expenditure share equations. Since all the expenditure share equations in the alternative Lewbel models are shown to be nonlinearly cointegrated, we may apply the error correcting method proposed by Phillips (1991). This is accomplished by incorporating the first-order autoregressive scheme into the model to correct for serial correlation.

For a complete demand model for all fats and oils, we estimated and compared six alternative models with and without AR (1). Two demographic variables were incorporated, both of which were considered to have significant influence on preferences. These variables were the food-away-from-home ratio (FAFHR) out of total food expenditure and family size (SIZE). A fat and cholesterol information index in Japan (FCIIJ), constructed using a geometrically decreasing function, was incorporated to reflect Japanese consumers' growing health concerns about fat and cholesterol. The models were estimated, using the iterative nonlinear seemingly unrelated regression (ITNSUR).

The Wald test results strongly reject both the Translog and AIDS in favor of the Lewbel model. The results also show that the Translog model was rejected more strongly than the AIDS model. Thus, the AIDS models are somewhat superior to the Translog model, but they are significantly different from the general Lewbel model. For the reminder of this paper, our discussion focuses only on the results obtained from the Lewbel model.

The computed uncompensated price and total expenditure elasticities are presented in Table 1 while the elasticities with respect to three demographic and fat and cholesterol information variables are shown in Table 2. All own-price elasticities have a negative sign as theoretically expected. Expenditure elasticities are positive for soybean-rapeseed oil, hog grease-beef tallow, fish oil, safflower oil, and butter, but negative for palm oil and rice-corn-cottonseed oil. The AR (1) specification reversed the signs of the expenditure elasticities for safflower oil from negative to positive. In addition, all the elasticities of each fat and oil with respect to the fat and cholesterol information index have the same signs regardless whether or not the AR (1) was imposed. However, the magnitudes of the elasticities vary substantially between the two specifications of the error structure.

The demands for fats and oils are all inelastic with respect to their own prices, except for safflower oil. All the fats and oils have positive expenditure elasticities except palm oil and rice bran-corn-cottonseed oils. Palm oil can be considered as an inferior oil, which is consistent with the results from U.S. fats and oils demand study conducted by Yen and Chern (1992). In Japan, safflower oil can be considered as a luxury oil since it is often purchased as gift items at Christmas and other bonus-paying seasons. The high expenditure elasticity of butter also indicates that butter has a strong income effect in Japan.

In terms of cross-price elasticities, soybean-rapeseed oils are substitutes for rice bran-corn-cottonseed oils, while they are complements for such animal fats as hog grease-beef tallow, butter, and palm oil. Hog grease-beef tallow is a substitute for only palm oil, but it is a complement for all other vegetable oils and animal fats. Butter can be considered as a complement for fish oil, and rice bran-corn-cottonseed oils.

Table 1. Price and Total Expenditure Elasticities, Lewbel Model.

					Price	of			
Products	Model	Soy + Rape	Hog + Tallow	Palm	Fish	Rice + Corn +	Safflow	Butter	Expen-diture
Soybean + Rapeseed Oil	Lewbel	-0.404	-0.028	-0.029	-0.011	-0.012	0.014	-0.272	0.743
	Lewbel + AR1	-0.278	-0.025	-0.017	-0.022	-0.015	0.037	-0.276	0.598
Hog Grease + Beef Tallow	Lewbel	-0.539	-0.358	0.265	-0.167	-0.415	0.047	-0.270	1.439
	Lewbel + AR1	-0.532	-0.309	0.237	-0.140	-0.338	-0.030	-0.196	1.310
Palm Oil	Lewbel	0.748	0.920	-0.859	0.532	0.364	-1.074	1.115	-1.747
	Lewbel + AR1	0.361	0.762	-1.019	0.551	0.377	-0.821	0.473	-0.686
Fish Oil	Lewbel	-0.845	-0.547	0.521	-0.927	-0.135	1.041	-1.058	1.951
	Lewbel + AR1	-0.935	-0.443	0.586	-0.895	-0.049	0.902	-0.712	1.546
Rice + Corn + Cotton Oils	Lewbel	0.398	-0.208	0.066	0.017	-0.303	0.298	-0.089	-0.178
	Lewbel + AR1	0.514	-0.124	0.111	0.040	-0.251	0.260	0.050	-0.600
Safflower Oil	Lewbel	9.154	-8.574	5.562	4.371	-5.548	-3.561	1.528	-0.455
	Lewbel + AR1	-6.735	8.212	-7.403	-4.357	4.500	-3.299	-0.052	3.668
Butter	Lewbel	-1.234	-0.131	0.014	-0.106	-0.251	0.066	-0.496	2.139
	Lewbel + AR1	-1.353	-0.125	-0.028	-0.085	-0.247	0.023	-0.400	2.216

Note: All elasticities are computed at sample means.

Table 2. Elasticities with respect to Demographic Variables and Fat and Cholesterol Information Index, Lewbel Model.

Products	Model	Demographic and Fat &Cholesterol Information Variables		
		FAFH Ratio	Family Size	G20
Soybean + Rapeseed	Lewbel	0.744	-0.107	-0.046
Oil	Lewbel + AR1	1.016	0.118	-0.043
Hog Grease +	Lewbel	-1.801	-1.204	-0.018
Beef Tallow	Lewbel + AR1	-1.798	-1.704	-0.044
Palm Oil	Lewbel	2.593	-7.221	-0.569
	Lewbel + AR1	1.707	-5.643	-0.469
Fish	Lewbel	0.153	2.847	0.182
Oil	Lewbel + AR1	0.127	2.051	0.213
Rice Bran +				
Corn +	Lewbel	1.234	1.723	0.005
Cottonseed	Lewbel + AR1	1.622	1.500	0.028
Oils				
Safflower	Lewbel	6.836	13.648	-0.267
Oil	Lewbel + AR1	0.984	5.909	-0.493
Butter	Lewbel	-2.223	-0.631	0.161
	Lewbel + AR1	-2.346	-0.300	0.156

Note: All elasticities are computed at sample means.

The estimation results suggest that as the percentage of food consumed away from home (FAFHR) increases, consumption of soybean-rapeseed oils, palm oil, fish oil, and rice bran-corn-cottonseed oils also tend to increase; Hog grease-beef tallow and butter tend to decrease. The estimation results also suggest that as family size decreases, soybean-rapeseed oils, fish oil, rice bran-corn-cottonseed oils and safflower oil would tend to decrease, whereas the other fats and oils would tend to increase. In addition, larger family size was found to be associate with higher consumption of such vegetable oils as soybean-rapeseed oils and rice bran-corn-cottonseed oils, but negatively associated with the consumption of such animal fats as hog grease-beef tallow

In terms of elasticities with respect to the fat and cholesterol information index, both Lewbel models with and without a correction of serial correlation indicate positive elasticities for fish oil, rice bran-corn-cottonseed oils and butter, but negative elasticities for other fats and oils.

These results suggest that Japanese consumers' growing health concerns about fat and cholesterol have induced an increase in consumption of fish oil, rice bran-corn-cottonseed oils and butter, and a decrease in consumption of all other fats and oils.

Conclusions

In the first model for soybean and rapeseed oils, the empirical results showed all variables to be identified as unit-root nonstationary. Also, cointegration relationships were shown to exist, based on both residual based tests. Therefore, the cointegration regression using OLS may yield super-consistent estimates, and reflect the long-run relationship among individual non-stationary time series.

The declining market share of soybean oil relative to rapeseed oil has been caused by increasing total meat imports induced by meat trade liberalization in 1988. Consumers' health information on fat and cholesterol has not had significant impacts on the demand for either soybean oil or rapeseed oil.

A model specification test indicates that the general Lewbel model outperforms both the AIDS and Translog models. The test results for unit-root nonstationarity of all the variables in the Lewbel model showed that they are all integrated of order one, with or without a drift based on the DF and PP tests. The test results for cointegration indicated that there exists cointegration relationships for all the expenditure share equations in the Lewbel models although the expenditure shares are nonlinearly related to all the explanatory variables.

The demand for fats and oils are all inelastic with respect to their own prices except for safflower oil. All the fats and oils have positive expenditure elasticities except palm oil and rice bran-corn-cottonseed oils. Palm oil is shown to be an inferior oil, while safflower oil shown to be a luxury oil. The high expenditure elasticity of butter shows that butter has a strong income effect in Japan. In terms of cross-price elasticities, soybean-rapeseed oils are substitutes for rice bran-corn-cottonseed oils, while they are complements for such animal fats as hog grease-beef tallow, butter, and palm oil.

The estimation results provided positive elasticities for fish oil and rice bran-corn-cottonseed oils and butter, but negative elasticities for other fats and oils in terms of the elasticities with respect to fat and cholesterol information variable.

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